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APPENDIX A
Big Spring Creek Inventory and Assessment Data, Fergus County Conservation District, June 1990

Table A-1. Stream Inventory and Assessment Results for Upper Big Spring Creek (modified from Hawn et al., 1990).

	Photo Number	Stream Length (ft)	Blanket Rock Riprap (ft)	Eroding Bank Left (ft)	Eroding Bank Right (ft)	Streambank Failure Left (ft)	Streambank Failure Right (ft)	Bank Mass Wasting (ft)
Upper Reach	197	4,650	180	0	0	120	0	0
	195	6,040	0	0	0	380	290	0
Big Springs	193	6,060	270	150	80	550	680	0
to	191	6,600	640	380	340	660	840	0
Lewistown	189	7,440	500	120	140	940	1,210	0
	187	6,940	260	380	200	1,210	380	0
	185	5,460	0	0	460	140	220	0
	183	6,760	720	200	390	0	0	0
	181	3,440	690	0	0	0	0	0
	179	5,760	1,940	100	0	160	0	0
Reach totals		**59,150**	**5,200**	**1,330**	**1,610**	**4,160**	**3,620**	**0**

Table A-2. Stream Inventory and Assessment Results for Upper Big Spring Creek (modified from Hawn et al., 1990).

	Photo Number	Stream Length (ft)	Blanket Rock Riprap (ft)	Eroding Bank Left (ft)	Eroding Bank Right (ft)	Streambank Failure Left (ft)	Streambank Failure Right (ft)	Bank Mass Wasting (ft)
Middle Reach	179	1800	1,660	100	0	0	0	0
	177	1340	740	250	0	580	540	0
Lewistown	175	5600	3,140	140	370	600	300	0
to	173	4000	1,400	40	260	810	500	0
Cottonwood Creek	171	8100	0	880	540	0	0	0
	169	5480	0	350	450	0	0	0
	167	4600	120	790	520	0	0	0
	165	4150	100	50	0	0	0	0
	163	5200	60	970	420	0	0	0
	162	220	0	460	70	390	160	0
	161	5350	0	450	550	740	440	0
	159	4700	20	80	0	0	0	0
	157	1550	0	0	20	490	690	0
Reach totals		**52,090**	**7,240**	**4,560**	**3,200**	**3,610**	**2,630**	**0**

Table A-3. Stream Inventory and Assessment Results for Lower Big Spring Creek (modified from Hawn et al., 1990).

	Photo Number	Stream Length (ft)	Blanket Rock Riprap (ft)	Eroding Bank Left (ft)	Eroding Bank Right (ft)	Streambank Failure Left (ft)	Streambank Failure Right (ft)	Bank Mass Wasting (ft)
Lower Reach	157	3,380	420	720	460	0	0	0
	155	5,880	0	440	200	0	260	0
Cottonwood Creek	153	4,140	0	160	520	0	0	0
to	151	6,050	60	0	550	840	880	1,050
Judith River	149	4,780	270	730	1,070	620	1,730	620
	148	2,160	0	0	0	1,500	0	850
	147	4,380	220	590	220	320	1,490	890
	145	5,820	0	810	380	240	930	180
	143	5,180	0	490	1,020	0	60	530
	141	9,800	0	2,330	3,190	140	80	0
Reach totals		**51,570**	**970**	**6,270**	**7,610**	**3,660**	**5,430**	**4,120**

Table A-4: Stream Inventory and Assessment Summary Results for Big Spring Creek (modified from Hawn et al., 1990).

Entire Length Big Spring Creek		Photo Length (ft)	Blanket Rock Riprap (ft)	Eroding Bank Left (ft)	Eroding Bank Right (ft)	Streambank Failure Left (ft)	Streambank Failure Right (ft)	Bank Mass Wasting (ft)
Totals		162,810	13,410	12,160	12,420	11,430	11,680	4,120
Percent of total			8%	7%	8%	7%	7%	3%

APPENDIX B

BIG SPRING CREEK TMDL TECHNICAL ASSISTANCE AERIAL PHOTOGRAPHY ASSESSMENT (FINAL)

Big Spring Creek

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FIGURES AND TABLES

FIGURES

All Figures are provided separately.

TABLES

1.0 INTRODUCTION

This report presents the results of a remote assessment of channel and riparian vegetation conditions that was conducted for Big Spring Creek in central Montana. This assessment of Big Spring Creek is a portion of the assessment of Big Spring Creek and three of its tributary streams: Cottonwood Creek, Beaver Creek and East Fork of Big Spring Creek. Big Spring Creek is a tributary to the Judith River and is located in Central Montana near Lewistown. Under Section 303(d) of the Clean Water Act, three of the above streams, Big Spring Creek, Cottonwood Creek and Beaver Creek, are listed on the 2002 Montana 303(d) List. Existing data on the East Fork of Big Spring Creek were insufficient for making a beneficial use support determination in 2002, and the stream was scheduled for reassessment. **Table 1-1** summarizes 303(d) status of the streams assessed in this report.

Table 1-1 ***303(d) Status of Big Spring Creek and Selected Tributaries in 2002.***

Stream	Beneficial Uses Impacted	Probable Causes	Probable Sources
Big Spring Creek	Aquatic Life Cold Water Fishery	Fish Habitat Degradation Nutrients PCBs Riparian Degradation Sedimentation	Municipal Point Sources Agriculture Grazing Land Disposal Septic Systems Hydromodification Channelization
Cottonwood Creek	Aquatic Life Cold Water Fishery Drinking Water Supply Industrial Recreation	Dewatering Fish Habitat Degradation Flow Alteration Nutrients Organic Enrichment Riparian Degradation Sedimentation	Agriculture Grazing Hydromodification Habitat Modification Removal of Riparian Vegetation
Beaver Creek	Aquatic Life Cold Water Fishery Drinking Water Supply Recreation	Bank erosion Dewatering Fish habitat degradation Flow alteration Nutrients Riparian Degradation Sedimentation	Agriculture Grazing Habitat Modification Removal of Riparian Vegetation
East Fork of Big Spring Creek	Scheduled for Reassessment	Scheduled for Reassessment	Scheduled for Reassessment

According to the Montana Water Quality Act, the State of Montana must monitor the extent to which the state's surface water bodies support legally designated beneficial uses. As part of this monitoring, the state must develop Total Maximum Daily Loads (TMDLs) and associated water quality restoration plans for Montana water bodies in which one or more pollutants impair designated beneficial uses. The Montana Department of Environmental Quality (MDEQ) will be developing a TMDL for Big Spring Creek Planning Area.

2.0 METHODS

Black and white stereo aerial photography, 7.5-minute topographic maps and planimetric maps were used to delineate the target streams into relatively homogeneous reaches. Reach breaks were established using the following criteria: 1) at status boundaries as delineated by the applicable planimetric map, 2) at significant changes in channel slope, valley type, 3) at functional changes in riparian vegetation and 4) at the confluence of major tributary streams. Reach names and breaks were transcripted onto the topographic maps and aerial photos. **Table 2-1** provides a summary of the topographic and planimetric maps used for each target stream.

Table 2-1 ***Map Summary***

Stream	Topographic Map(s)	Planimetric Map(s)
Big Spring Creek	Danvers Spring Creek Junction Glengarry Lewistown Pike Creek	BLM Lewistown 1:100,000-scale planimetric map
Cottonwood Creek	Spring Creek Junction Glengarry West Fork Beaver Creek Castle Butte Jump Off Peak	BLM Lewistown 1:100,000-scale planimetric map
Beaver Creek	Glengarry West Fork Beaver Creek Castle Butte	Lewis and Clark National Forest Forest Visitors Map
E. Fork of Big Spring Creek	Heath Half Moon Canyon	BLM Big Snowy 1:100,000-scale planimetric map

Within each reach, aerial photography was used to characterize and assess several parameters (described below in **Section 2.1**) pertaining to channel and riparian vegetation condition for each target stream. The dates of the aerial photographs varied somewhat between the streams: aerial photo coverage from June 6, 1989 was used to assess Big Spring Creek; aerial photos taken on May 30, 1995 were used to assess the three target tributaries to Big Spring Creek. All aerial photographs were at a scale of 1:6,000.

Each target stream was assessed from its mouth to its headwaters, with the exception of East Fork of Big Spring Creek where aerial photo coverage was not available for approximately the lower eight miles of the stream. Because of the lack of photo coverage these eight miles were not included in this assessment.

2.1 Assessment Parameters

The following parameters were included in the aerial photo assessment:

2.1.1 Reach Information

Reach Name: Consists of the first three letters of the target stream name followed by a number (e.g. COT14). Reaches are numbered consecutively from the stream's mouth to its headwaters.

Reach Length (ft): The linear length of the specified stream reach. Measured to the nearest foot using a digital planimeter and topographic map.

2.1.2 Riparian Vegetation Area

Buffer Width: Measured to the nearest 5 feet to a maximum of 50 feet. An average width of the riparian vegetation buffer adjacent to both sides of the stream in the delineated reach.

Vegetation Type (%): Occularly assessed from the aerial photos. Types included (within a 50' buffer): 1) Conifers and Deciduous Trees, 2) Woody Shrubs, 3) Grass/Sedge (groundcover), 4) Bare ground/Disturbed and 5) Impervious/Urban.

Vegetation Condition: This parameter was replaced by "Vegetation Impact Category", described below. The replacement was made to more accurately organize and compare the reaches. This parameter appears on the data collection forms, but no data were collected.

Degraded Riparian Vegetation: number of feet of stream bank (both sides) with human-impacts to riparian vegetation. Impacts included: 1) areas that had physically observable damaged riparian communities (e.g. trampled), 2) complete lack of riparian vegetation and 3) no woody vegetation observable on banks where such vegetation would be expected based on comparison with upstream/downstream reaches. Impacted riparian vegetation areas were transcribed onto topographic maps and impacted areas were measured to the nearest decimal foot with GIS. The percentage of the reach with degraded riparian vegetation was then calculated by the following formula:

(feet degraded riparian vegetation) / (feet of stream bank, both sides) = % of the reach impacted

Vegetation Impact Category: The reaches were ranked according to the level (% of reach) of impacts and assigned to an impact category according to the following criteria: 1) degraded riparian conditions along 50% or more of the reach indicates a **Highly Impacted** condition; 2) degraded riparian conditions along 25-49% of the reach indicates a **Moderately Impacted** condition; and 3) degraded riparian conditions along 1-24% of the reach indicates a **Lightly Impacted** to riparian vegetation condition. Only reaches with no observable impacts to riparian vegetation (% of reach impacted = 0) were ranked as **Not Impacted**.

2.1.3 Channel Condition

Sinuosity: Sinuosity = reach channel length / reach valley length (as measured from an aerial photo)

Valley Gradient or Slope (%): Gradient = change in elevation in feet / distance of elevation change in feet (measured between contour intervals from the topographic map)

Rosgen Type (Level 1): Stream channel classification based on channel slope, sinuosity, valley type, stream pattern and form (Rosgen, 1996).

Rosgen Type Potential (Level 1): Potential (future) Rosgen stream classification based on occular evidence of natural stream geomorphologic transition *or* evidence of a degraded stream condition that with improvement would have a different stream classification

Channel Degradation: Evidence of the following channel degradation characteristics on an aerial photo: 1) Rip rap, 2) Channelization, 3) Unstable Banks, 4) Severely Eroding Banks. Unstable banks were characterized as those with ocular evidence of light to moderate erosion, while severely eroding banks were characterized as those with evidence of wider scale bank slumping, mass wasting or bank failure.

Impacted channel areas were transcribed onto topographic maps and impacted areas were measured to the nearest decimal foot with GIS. The percentage of the reach with each of the above channel characteristics was then calculated by the following formula:

(feet of channel characteristic) / (feet of stream bank, both sides) = % of the reach impacted

Overall Channel Condition: This parameter was replaced by "Channel Impact Category", described below. The replacement was made to more accurately organize and compare the reaches. This parameter appears on the data collection forms, but no data were collected.

Channel Impact Category: The reaches were ranked according to the cumulative score of *anthropogenic* impacts created by the summation of % of each reach in the four channel degradation parameters (rip rap, channelization, unstable banks, severely eroding banks): reaches with a cumulative score greater than 50 were labeled as **Highly Impacted;** reaches with a score of 25 to 49 were labeled as **Moderately Impacted**; reaches with a score of 1 to 24 were labeled as **Lightly Impacted**; reaches with a score of 0 were labeled as **Not Impacted**. In calculating the channel impact score, the eroding stream banks that appeared to result from naturally erodible bank terraces were removed so that only anthropogenic impacts were included.

Meander Cutoff Potential: Subjective rating of Low, Medium or High potential that a stream meander will be cut off in the future due to erosion/deposition.

2.1.4 General Characteristics

Reference Potential: Whether or not the reach could be considered *reference*, or a reach representing "ideal" or least impacted channel and vegetation characteristics

Land Use: Adjacent anthropogenic or natural land use characteristics that may be contributing to water quality impairment and/or bank instability. Land use comments were transcripted onto aerial photos.

3.0 IMPACT SUMMARY

3.1 Big Spring Creek

This section presents a summary and analysis of selected riparian and channel condition variables. **Appendix B** presents a tabular summary of all of the data collected on Big Spring Creek.

3.1.1 Riparian Vegetation Impacts

Table 3-1 provides a summary of selected characteristics of riparian vegetation on Big Spring Creek. The majority of the reaches were classified as Highly and Moderately Impacted, indicating riparian degradation between 25 and 50 percent of the reach. Big Spring Creek reaches that were ranked as Lightly Impacted or Not Impacted will be considered "Vegetation Reference Reaches" for the purposes of this assessment (**Section 4.0**).

Table 3-1 ***Riparian Vegetation Characteristics – Big Spring Creek***

Reach	Total Bank Length (ft)	Buffer Width (ft)	Vegetation Type (% of reach)					Degraded Riparian Vegetation (% of reach)	Vegetation Impact Category
			Con/Dec	Woody Shrub	Bare ground/ disturbed	Grass/ Sedge	Impervious/ Urban		
BIG26	10758	0	10	0	0	0	90	100	Highly Impacted
BIG25	8246	5	15	10	10	65	0	98	Highly Impacted
BIG1	4228	10	0	20	20	60	0	96	Highly Impacted
BIG7	4460	15	0	20	20	60	0	93	Highly Impacted
BIG5	5594	0	10	10	5	65	10	92	Highly Impacted
BIG10	12852	30	25	20	20	20	15	76	Highly Impacted
BIG18	14930	15	10	30	10	30	20	75	Highly Impacted
BIG19	6476	25	10	25	10	55	0	69	Highly Impacted
BIG23	16006	30	10	30	10	50	0	64	Highly Impacted
BIG8	10406	25	5	25	30	20	20	62	Highly Impacted
BIG11	11010	40	15	15	10	55	5	62	Highly Impacted
BIG3	7318	25	5	20	20	55	0	61	Highly Impacted
BIG12	8544	25	5	30	5	60	0	60	Highly Impacted
BIG20	12222	40	15	40	10	35	0	55	Highly Impacted
BIG13	7538	50	25	40	15	20	0	54	Highly Impacted
BIG6	7790	15	5	30	10	45	10	51	Highly Impacted
BIG4	5134	50	5	50	5	35	5	49	Moderately Impacted
BIG2	6990	40	0	30	10	60	0	47	Moderately Impacted
BIG24	11644	40	30	30	10	30	0	44	Moderately Impacted
BIG9	5300	40	0	15	20	65	0	43	Moderately Impacted
BIG16	13850	50	35	35	0	30	0	42	Moderately Impacted
BIG17	10918	40	20	40	15	25	0	40	Moderately Impacted
BIG29	10102	20	10	30	0	50	10	40	Moderately Impacted
BIG32	6108	25	20	40	0	30	10	38	Moderately Impacted
BIG15	15746	>50	30	30	10	30	0	36	Moderately Impacted
BIG30	11748	35	20	30	0	45	5	33	Moderately Impacted
BIG33	11610	25	10	30	10	40	10	33	Moderately Impacted
BIG14	12296	35	20	30	10	40	0	32	Moderately Impacted
BIG27	13268	30	10	30	0	40	20	27	Moderately Impacted
BIG21	11628	50	30	40	5	25	0	26	Moderately Impacted
BIG28	12462	25	10	20	0	45	25	19	Moderately Impacted*
BIG31	3962	50	0	50	0	45	5	21	Lightly Impacted
BIG22b	12998	25	15	35	5	45	0	20	Lightly Impacted
BIG35	13670	50	10	35	5	40	10	13	Lightly Impacted
BIG22a	9224	40	40	30	0	30	0	11	Lightly Impacted
BIG34	9824	40	10	45	0	45	0	0	Not Impacted

* Downgraded to Moderately Impacted due to 25% impervious/urban surface

3.1.2 Stream Channel Characteristics

Table 3-2 provides a summary of selected stream channel characteristics of Big Spring Creek. As was the case with the riparian vegetation, most of the reaches fell into the Highly and Moderately Impacted categories. There were no reaches that were considered Not Impacted. Big Spring Creek reaches that were ranked as Lightly Impacted will be considered "Channel Reference Reaches" for the purposes of the Discussions and Recommendations section of this report (**Section 4.0**). Note that the Cumulative Channel Impact Score is the sum of the four Channel Degradation Characteristics minus the portion of the eroding banks that were classified as natural erosion from unvegetated terraces.

Table 3-2 ***Stream Channel Characteristics – Big Spring Creek***

Reach	Total Bank Length (ft)	Channel Degradation Characteristics (% of reach)				Minus (-) "Natural" Erosion (%)	Cumulative Channel Impact Score	Channel Impact Category
		Rip rap	Channelized	Unstable Banks	Severely Eroding Banks			
BIG25	8246	18	98	0	8	0	125	Highly impacted
BIG26	10758	8	97	4	0	0	109	Highly impacted
BIG6	7790	0	0	68	16	3	81	Highly impacted
BIG28	12998	2	79	0	0	0	81	Highly impacted
BIG18	14930	4	24	43	9	0	80	Highly impacted
BIG11	11010	0	43	18	11	0	73	Highly impacted
BIG19	6476	0	0	64	8	0	72	Highly impacted
BIG7	4460	0	0	46	24	0	70	Highly impacted
BIG1	4228	0	0	34	35	0	69	Highly impacted
BIG10	12852	0	0	58	16	7	67	Highly impacted
BIG5	5594	0	0	35	25	0	60	Highly impacted
BIG3	7318	0	0	38	20	0	58	Highly impacted
BIG23	16006	22	17	9	4	0	52	Highly impacted
BIG12	8544	0	0	30	28	7	51	Moderately impacted
BIG20	12222	0	26	9	16	0	51	Moderately impacted
BIG4	5134	0	0	51	23	28	46	Moderately impacted
BIG8	10406	0	0	33	19	7	46	Moderately impacted
BIG9	5300	0	0	12	31	0	43	Moderately impacted
BIG14	7538	2	0	29	13	2	42	Moderately impacted
BIG13	12296	0	0	27	14	0	42	Moderately impacted
BIG2	6990	0	0	57	33	49	41	Moderately impacted
BIG15	15746	2	0	25	9	0	35	Moderately impacted
BIG35	13670	2	24	2	6	0	33	Moderately impacted
BIG21	11628	4	0	22	4	0	31	Moderately impacted
BIG16	13850	0	0	24	4	0	28	Moderately impacted
BIG34	9824	0	25	0	3	0	28	Moderately impacted
BIG29	10102	1	10	2	9	0	22	Lightly Impacted
BIG27	13268	12	0	0	7	0	19	Lightly Impacted
BIG30	11748	0	0	13	6	0	19	Lightly Impacted
BIG22a	9224	0	0	11	7	0	18	Lightly Impacted
BIG17	10918	0	0	6	12	0	17	Lightly Impacted
BIG33	11610	3	0	7	7	0	16	Lightly Impacted
BIG24	11644	6	0	3	3	0	13	Lightly Impacted
BIG32	6108	0	0	6	7	0	12	Lightly Impacted
BIG31	12462	0	0	10	1	0	11	Lightly Impacted
BIG22b	3962	0	0	4	6	0	10	Lightly Impacted

Table 3-3 provides a comparison of Vegetation and Channel Impact ratings, listed from the most highly impacted to the least impacted. In general, vegetation and channel conditions in each reach were within one impact category of one another. The exception was BIG34, where the vegetation was not impacted but the channel was moderately impacted.

Table 3-3 ***Vegetation/Channel Impact Comparison - Big Spring Creek***

Reach	Vegetation Impact Category	Channel Impact Category	Reach	Vegetation Impact Category	Channel Impact Category	Reach	Vegetation Impact Category	Channel Impact Category
BIG1	Highly Impacted	Highly Impacted	BIG8	Highly Impacted	Moderately Impacted	BIG17	Moderately Impacted	Lightly Impacted
BIG3	Highly Impacted	Highly Impacted	BIG12	Highly Impacted	Moderately Impacted	BIG24	Moderately Impacted	Lightly Impacted
BIG5	Highly Impacted	Highly Impacted	BIG13	Highly Impacted	Moderately Impacted	BIG27	Moderately Impacted	Lightly Impacted
BIG6	Highly Impacted	Highly Impacted	BIG20	Highly Impacted	Moderately Impacted	BIG29	Moderately Impacted	Lightly Impacted
BIG7	Highly Impacted	Highly Impacted	BIG28	Moderately Impacted	Highly Impacted	BIG30	Moderately Impacted	Lightly Impacted
BIG10	Highly Impacted	Highly Impacted	BIG2	Moderately Impacted	Moderately Impacted	BIG32	Moderately Impacted	Lightly Impacted
BIG11	Highly Impacted	Highly Impacted	BIG4	Moderately Impacted	Moderately Impacted	BIG33	Moderately Impacted	Lightly Impacted
BIG18	Highly Impacted	Highly Impacted	BIG9	Moderately Impacted	Moderately Impacted	BIG35	Lightly Impacted	Moderately Impacted
BIG19	Highly Impacted	Highly Impacted	BIG14	Moderately Impacted	Moderately Impacted	BIG22a	Lightly Impacted	Lightly Impacted
BIG23	Highly Impacted	Highly Impacted	BIG15	Moderately Impacted	Moderately Impacted	BIG22b	Lightly Impacted	Lightly Impacted
BIG25	Highly Impacted	Highly Impacted	BIG16	Moderately Impacted	Moderately Impacted	BIG31	Lightly Impacted	Lightly Impacted
BIG26	Highly Impacted	Highly Impacted	BIG21	Moderately Impacted	Moderately Impacted	BIG34	Not Impacted	Moderately Impacted

3.1.3 Previous Assessments

The Fergus County Conservation District performed a Stream Inventory and Assessment of Big Spring Creek in 1990. The 1990 Inventory was performed on the ground. Observations that could be compared with Land & Water's assessment of Big Spring Creek are summarized below in **Table 3-4**.

Table 3-4 ***1990 Stream Inventory and Assessment (Fergus County) - Big Spring Creek***

Source	"Bank erosion+failure+mass wasting" (ft)	Rip rap (ft)
1990 Inventory	50,730	13,410
Land & Water Equivalent	108,992 (Unstable banks+Severely Eroding Banks)	10,822

All data includes both natural and anthropogenic sources

Land & Water's comparison value for unstable or eroding banks is more than twice the value than that found by the Fergus County inventory. The reasons for the different findings are not clear, but likely result from the different methodologies employed in the two assessments. No information regarding the methods used by the Fergus County Conservation District or how the District defined eroding banks was found for this report.

4.0 DISCUSSION/RECOMMENDATIONS

4.1 Relationship of Riparian Vegetation Characteristics with Channel Erosion

Select riparian characteristics were compared to the total percentage of unstable and eroding banks in each reach in order to provide a quantitative estimate of the correlation between riparian vegetation and bank stability (**Table 4-1**). The combined % of unstable and eroding banks was sorted and divided in quartiles, and the data presented in **Table 4-1** are presented separately for each of these quartiles. Few if any connections between vegetation condition and bank stability are obvious from this comparison, suggesting that a more complicated set of circumstances controls bank stability on Big Spring Creek.

Table 4-1 ***Comparison Between Riparian Vegetation Characteristics and Channel Erosion - Big Spring Creek***

	Riparian Vegetation Characteristics						
Reach	**Buffer Width (ft)**	**Con/Dec (% of reach)**	**Woody Shrub (% of reach)**	**Bare ground/ disturbed (% of reach)**	**Grass/ Sedge (% of reach)**	**Impervious/ Urban (% of reach)**	**Combined Unstable/Eroding Banks (% of reach)**
BIG2	40	0	30	10	60	0	90
BIG6	15	5	30	10	45	10	84
BIG4	50	5	50	5	35	5	74
BIG10	30	25	20	20	20	15	74
BIG19	25	10	25	10	55	0	72
BIG7	15	0	20	20	60	0	70
BIG1	10	0	20	20	60	0	69
BIG5	0	10	10	5	65	10	60
BIG3	25	5	20	20	55	0	58
Averages Quartile 4	*23*	*7*	*25*	*13*	*51*	*4*	*72*
BIG12	25	5	30	5	60	0	58
BIG8	25	5	25	30	20	20	53
BIG18	15	10	30	10	30	20	52
BIG9	40	0	15	20	65	0	43
BIG13	50	25	40	15	20	0	42
BIG14	35	20	30	10	40	0	42
BIG15	>50	30	30	10	30	0	33
BIG11	40	15	15	10	55	5	29
BIG16	50	35	35	0	30	0	28
Averages Quartile 4	*35*	*16*	*28*	*12*	*39*	*5*	*42*
BIG21	50	30	40	5	25	0	27
BIG20	40	15	40	10	35	0	25
BIG30	35	20	30	0	45	5	19
BIG22a	40	40	30	0	30	0	18
BIG17	40	20	40	15	25	0	17
BIG23	30	10	30	10	50	0	13
BIG33	25	10	30	10	40	10	13
BIG32	25	20	40	0	30	10	12
Averages Quartile 4	*36*	*21*	*35*	*6*	*35*	*3*	*18*

Table 4-1 ***Comparison Between Riparian Vegetation Characteristics and Channel Erosion - Big Spring Creek (continued)***

	Riparian Vegetation Characteristics (continued)						
Reach	**Buffer Width (ft)**	**Con/Dec (% of reach)**	**Woody Shrub (% of reach)**	**Bare ground/ disturbed (% of reach)**	**Grass/ Sedge (% of reach)**	**Impervious/ Urban (% of reach)**	**Combined Unstable/Eroding Banks (% of reach)**
BIG29	20	10	30	0	50	10	11
BIG31	50	0	50	0	45	5	11
BIG22b	25	15	35	5	45	0	10
BIG25	5	15	10	10	65	0	8
BIG27	30	10	30	0	40	20	7
BIG35	50	10	35	5	40	10	7
BIG24	40	30	30	10	30	0	6
BIG26	0	10	0	0	0	90	4
BIG34	40	10	45	0	45	0	3
BIG28	25	10	20	0	45	25	0
Averages Quartile 4	*29*	*12*	*29*	*3*	*41*	*16*	*7*

4.2 Characteristics of Reference Reaches

Vegetation and Channel Reference Reaches were identified for Big Spring Creek to provide a gauge for forming restoration targets. As was discussed in **Section 3.1.1** and **3.1.2**, reference reaches are those that were classified as Lightly or Not Impacted in the vegetation condition assessment and Lightly Impacted in the channel condition assessment. The reference reaches occur throughout the Middle and Upper regions of Big Spring Creek, but are absent from the lower third of the stream. A summary of the average characteristics of the reference reaches is presented for vegetation and channel conditions in **Table 4-2** and **4-3**, respectively.

Table 4-2 ***Vegetation Reference Reaches - Big Spring Creek***

Location on Big Spring Cr.	**Reach**	**Coniferous/Deciduous (%)**	**Woody Shrub (%)**	**Degraded Riparian Vegetation (%)**
Middle	BIG22a	40	30	11
Middle	BIG22b	15	35	20
Upper	BIG31	0	50	21
Upper	BIG34	10	45	0
Upper	BIG35	10	35	13
	averages	*15*	*39*	*13*
	TARGET	15% tree + 39% shrub = **54% tree/shrub types**		**Degraded Riparian Vegetation ≤ 13%**

Table 4-3 ***Channel Reference Reaches - Big Spring Creek***

Location on Big Spring Cr.	Reach	Channelization (%)	Unstable Banks (%)	Severely Eroding Banks (%)
Upper	BIG29	10	2	9
Upper	BIG27	0	0	7
Upper	BIG30	0	13	6
Middle	BIG22a	0	11	7
Middle	BIG17	0	6	12
Upper	BIG33	0	7	7
Middle	BIG24	0	3	3
Upper	BIG32	0	6	7
Upper	BIG31	0	10	1
Middle	BIG22b	0	4	6
	averages	1	6	7
	TARGET	**Channelized ≤ 1%**	6% unstable + 7% severely eroding = **Eroding Banks ≤ 13%**	

4.3 Comparison of Reference Reaches with Highly Degraded Reaches

The target conditions derived in **Tables 4-2 and 4-3** above were compared to the conditions in the most degraded reaches on Big Spring Creek. For Big Spring Creek, the "most degraded" reaches were defined to be those in which the vegetation condition and/or the channel condition were rated as Highly Impacted. These represent reaches of Big Spring Creek that appear to be in the greatest need of restoration and where the largest potential reductions in sediment loading could be achieved. **Table 4-4** summarizes the most degraded reaches and describes their land use characteristics. **Table 4-5** compares the most degraded reaches to reference conditions.

Table 4-4 ***"Most Degraded" Reaches – Big Spring Creek***

Reach	Location on Big Spring Cr.	Vegetation Impact Category	Channel Impact Category	Land Use Characteristics
BIG1	Lower	Highly Impacted	Highly Impacted	confluence w/Judith, livestock grazing
BIG3	Lower	Highly Impacted	Highly Impacted	livestock grazing, agr field 25' from LB road 80' from RB, vehicle access on RB
BIG5	Lower	Highly Impacted	Highly Impacted	livestock grazing, agr field 30' RB 2-track 25' RB, concentrated stock access point (3)
BIG6	Lower	Highly Impacted	Highly Impacted	livestock grazing, agr field <10' RB road 40' RB, pullout from road to RB concentrated stock access point (4)
BIG7	Lower	Highly Impacted	Highly Impacted	livestock grazing, agr field <10' LB concentrated stock access point (2)
BIG10	Lower	Highly Impacted	Highly Impacted	Spring Creek Colony farm operation Bridge, road/2-track 25' RB/LB concentrated stock access point (1) , agr field to bank edge, RB
BIG11	Lower	Highly Impacted	Highly Impacted	livestock grazing, agr fields <25', RB (2) vehicle fjord (2), road within 25', RB

Table 4-4 ***"Most Degraded" Reaches – Big Spring Creek (continued)***

Reach	Location on Big Spring Cr.	Vegetation Impact Category	Channel Impact Category	Land Use Characteristics
BIG18	Middle	Highly Impacted	Highly Impacted	ag. operation w/livestock grazing potential solid waste dumping over RB at ranch road/2-track to bank edge RB, bridges (2) intermittent stream joins RB, erosion upstream of confluence at RR bridge
BIG19	Middle	Highly Impacted	Highly Impacted	RR within 100' of 30% of reach, RB
BIG23	Middle	Highly Impacted	Highly Impacted	several small ranches riprap along majority of reach, RB/LB agr field to bank edge for most of RB
BIG25	Upper	Highly Impacted	Highly Impacted	Wastewater Treatment Plant LB, bridge, riprap majority of reach is lawn or agr field within 15',RB/LB
BIG26	Upper	Highly Impacted	Highly Impacted	residential and commercial urban landuse, majority of reach is channelized and concrete
BIG8	Lower	Highly Impacted	Moderately Impacted	roads to bank edge, RB/LB, bridge fields to bank edge, RB/LB (4)
BIG12	Lower	Highly Impacted	Moderately Impacted	livestock grazing agr fields to bank edge RB/LB (4), concentrated stock access point (1)
BIG13	Middle	Highly Impacted	Moderately Impacted	livestock grazing, agr field <50', LB (2) concentrated stock access points (5) bridges (2)
BIG20	Middle	Highly Impacted	Moderately Impacted	ranch operation w/livestock grazing agr fields to bank edge (7), RB/LB, concentrated stock access (2), bridge
BIG28	Upper	Moderately Impacted	Highly Impacted	confluence w/Casino Cr channelized between roads 80% of reach bridges (2)

LB = left bank
RB = right bank

Table 4-5 ***Comparison of Most Degraded Reaches with Target Conditions – Big Spring Creek***

	Target Variable	*Target Value (%)*	BIG1	BIG3	BIG5	BIG6	BIG7	BIG10	BIG11	BIG18	BIG19	BIG23	BIG25	BIG26	BIG8	BIG12	BIG13	BIG20	BIG28
Vegetation	**Tree/shrub Types**	*≥ 54*	20	25	25	35	20	45	30	40	35	40	25	10	30	35	65	55	30
	Degraded Riparian Vegetation	*≤ 13*	96	61	92	51	93	76	62	75	69	64	98	100	62	60	54	55	19
Channel	**Channelized**	*≤ 1*	0	0	0	0	0	0	43	24	0	17	98	97	0	0	0	26	79
	Eroding Banks	*≤ 13*	69	58	60	84	70	74	29	52	72	13	8	4	52	58	41	25	0

4.4 Restoration Focus Areas

4.4.1 <u>Previous Restoration Activities</u>

In 1995, the NRCS conducted several restoration projects on privately owned and state land on Big Spring Creek. **Table 4-6** describes the restoration projects that were detailed in the NRCS study. There was no information available regarding the success of these projects or describing whether the riparian management was continued past the 1995 study.

Table 4-6 ***1995 NRCS Restoration Projects***

Reach	Owner	Riparian Fencing (ft)	Channel Improved* (ft)	Stream/Riparian Improved* (ft)	Off-site Watering Locations Provided	Comments
BIG16	Don Jenni	None	100	2,300	One	Continue willow plantings
BIG20	Sam Weidner	7,915	None	5,940	One	Complete
BIG24	Emmet Butcher	3,300	None	4,620	One	Complete
BIG28	MT FWP	4,800	3,950	5,600	None	None
BIG33	George Hamilton	None	110	720	None	Conservation Easement on unit
BIG31	Ron Isackson	None	None	570	None	Complete

*No information was provided as to the improvement technique.

4.4.2 Restoration Priorities

For each of the “most degraded” reaches of Big Spring Creek described in **Section 4.3**, this section summarizes the major impacts observed during the air photo assessment. Because of their heavily impacted condition, these reaches represent the areas most likely in need of restoration.

BIG1 – This reach begins at the confluence of the Judith River and Big Spring Creek. The primary impact was to riparian vegetation; 96% of the riparian vegetation community was degraded and less than half the target value for tree/shrub types was observed. 69% of the channel was unstable or eroding, over five times the reference value for Big Spring Creek.

BIG3 – The channel and riparian impacts were similar but slightly less than the near downstream reach, BIG1 (above). The impacts to riparian vegetation and the channel in this reach were similar; 61% of the vegetation was degraded and 58% of the channel was degraded by evidence of grazing, agricultural fields to the bank edge and vehicle access across the stream. Less than half of the tree/shrub cover target was observed on this reach.

BIG5 – This reach is similar in characteristics to the downstream reaches BIG1 and BIG3 (above). The primary impact was to riparian vegetation; 92% of the riparian vegetation community was impacted by evidence of grazing, agricultural fields and dirt roads within 30 feet of the bank edge and concentrated stock access points. Less than half the target value for tree/shrub types was observed. 60% of the channel was unstable or eroding, over four times the reference value for Big Spring Creek.

BIG6 – BIG6 had a higher tree/shrub cover and nearly half the degraded riparian vegetation of the reaches listed above but a significantly higher (84%) amount of unstable or eroding banks. The reach was impacted by evidence of grazing, agricultural fields and dirt roads within 40 feet of the bank edge and concentrated stock access points.

BIG7 – With the exception of BIG6, this reach is similar in characteristics to the downstream reaches listed above. The primary impact was to riparian vegetation; 93% of the riparian vegetation community was impacted by evidence of grazing, agricultural fields within 10 feet of the bank edge and concentrated stock access points. Less than half the target value for tree/shrub types was observed. 70% of the channel was unstable or eroding, over five times the reference value for Big Spring Creek.

BIG10 - The impacts to riparian vegetation and the channel in this reach were similar; 76% of the vegetation was degraded and 74% of the channel was degraded. However, the tree/shrub percentage was within 10% of the target. The impacts were primarily due to the Spring Creek Colony farm located on the reach; roads and agricultural fields were observed within 10 feet of the bank edge. Evidence of grazing and concentrated stock access points were observed. Less than half of the tree/shrub cover target was observed on this reach.

BIG11 – The primary channel impacts to this reach were a result of channelization: 43% of the reach was channelized. 29% of the channel was unstable or eroding, which is within 16% of the target value. The tree/shrub cover was approximately 25% less than the target value, and 62% of the riparian vegetation on the reach was degraded. Evidence of grazing, roads and agricultural fields were observed within 25 feet of the bank. Restructuring of the channelized portions of the reach to a more sinuous condition will aid in reducing stream flow velocities.

BIG18 – Channel impacts included 24% channelization of the reach and 52% unstable or eroding banks. 75% of the vegetation was degraded and 40% tree/shrub cover was observed. Evidence of grazing, roads to the bank edge and the dumping of solid waste (riprap?) over the bank edge was observed associated with an agricultural operation. Restructuring of the channelized portions of the reach to a more sinuous condition will aid in reducing stream flow velocities.

BIG19 - The impacts to riparian vegetation and the channel in this reach were similar; 69% of the vegetation was degraded and 72% of the channel was degraded. The tree/shrub percentage was 35%. Railroad tracks ran approximately 100 feet from the reach. Enhancing the tree and woody shrub community where there is potential would aid in erosion reduction. Bank stabilization is recommended where possible.

BIG23 – The channel condition was relatively good; the percentage of unstable or eroding banks was at the target value and a small amount of the reach was channelized (17%). However, 22% of the reach was stabilized with riprap (**Table 3-2**). The primary impacts to the reach were to the riparian vegetation: 64% of the riparian vegetation was degraded. The tree/shrub cover was within 15% of the target. Several small ranches were located on the reach.

BIG25 and *BIG26* – These two reaches run through the city of Lewistown. Nearly all of each reach has little to no riparian vegetation and is completely channelized. Where possible, restoring some sinuosity to the stream and installing flow-reducing structures would reduce flow velocities that may cause erosion downstream. Establishing riparian communities within the new stream bends would aid in restoring some riparian function to these reaches.

BIG8 - The impacts to riparian vegetation and the channel in this reach were similar; 62% of the vegetation was degraded and 52% of the channel was degraded. Roads and agricultural fields were observed to the bank edge. Approximately 25% less than the tree/shrub cover target was observed on this reach.

BIG12 - The impacts to riparian vegetation and the channel in this reach were similar; 60% of the vegetation was degraded and 58% of the channel was degraded. Evidence of livestock grazing, concentrated stock access points and roads and agricultural fields to the bank edge were observed. Approximately 20% less than the tree/shrub cover target was observed on this reach.

BIG13 – This reach had a higher percentage of tree/shrub cover (65%) and lower amounts of degraded riparian vegetation and channel erosion than its adjacent downstream reach BIG12 (above). The tree/shrub cover is above the target value. Roads within 50 feet of the stream and evidence of livestock grazing was observed.

BIG20 – The tree/shrub cover on this reach was above the target value. 55% of the vegetation was degraded. 25% of the reach was unstable or eroding; however, 26% of the reach had been channelized. A ranch operation with evidence of grazing, concentrated stock access points and roads to the bank edge was observed.

According to the 1995 NRCS data, one off-site watering location, 7,915 feet of riparian fencing was installed in 1995 and 5,940 feet of the stream/riparian area was improved by the private landowner. No description of the improvements was provided.

BIG28 – The primary impact to this reach is the high degree of channelization: 79% of the reach is channelized between roads. The percentage of tree/shrub cover is 25% less than the target value.

According to the 1995 NRCS data, the Montana Fish, Wildlife and Parks installed 4,800 feet of riparian fencing, improved 3,959 feet of the channel and 5,600 feet of the stream/riparian area in 1995. No description of the improvements was provided.

5.0 CONCLUSIONS

Impacts to riparian vegetation appeared to be the greatest potential source of sediment input to the stream. The primary sources of vegetation impacts were related to land use: agriculture and grazing appeared to have had significant impacts to riparian communities on the lower and upper portions of Big Spring Creek while the urban landscape appeared to have replaced the riparian zone in and around Lewistown. Channelization was observed mostly in the urban portion of Big Spring Creek. These channelized areas will have a greater influence on sediment generation downstream, where higher stream velocities will result in increased bank erosion.

On the majority of the reaches, both the vegetation condition and the channel condition were classified as Highly and Moderately Impacted.

Select riparian characteristics were compared to the total percentage of unstable and eroding banks in each reach in order to provide a quantitative estimate of the correlation between riparian vegetation and bank stability. Few if any connections between vegetation condition and bank stability were obvious from the comparison, suggesting a more complicated set of circumstances controls bank stability on Big Spring Creek.

In general, Big Spring Creek was significantly impacted, with 34% of the banks in either unstable (22%) or severely eroding (12%) condition and nearly half of the riparian vegetation (47%) in degraded condition. The 12% of the stream that has been channelized will complicate restoration efforts, as such “hard” impacts are difficult and expensive to re-naturalize and can have systemic effects on sediment production.

Table 5-1 ***Summary of Degradation Statistics***

Degraded Riparian Vegetation	Riprap	Channelization	Unstable Banks	Severely Eroding Banks
47%	2%	12%	22%	12%

The air photo assessment that was conducted for this report was not at a scale that allows for detailed site-specific restoration recommendations. However, the following general recommendations could guide restoration efforts, particularly in those reaches identified in **Section 4.3** as “most degraded” and thus most in need of restoration:

- Restructuring of the channelized portions of the reach to a more sinuous condition to aid in reducing stream flow velocities;
- Providing at least a 50 foot vegetation buffer between Beaver Creek and fields/roads;
- Improving proper riparian function by providing off-site watering locations coupled with riparian fencing;
- Enhancing the tree and woody shrub community where there is potential to aid in erosion reduction or maintenance of bank stability; and
- Mechanical bank stabilization where possible

APPENDIX C

BIG SPRING CREEK TMDL TECHNICAL ASSISTANCE AERIAL PHOTOGRAPHY ASSESSMENT (FINAL)

Beaver Creek

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FIGURES AND TABLES

FIGURES

Associated Figures are provided separately.

TABLES

1.0 INTRODUCTION

This report presents the results of a remote assessment of channel and riparian vegetation conditions that was conducted for Beaver Creek, tributary to Big Spring Creek in central Montana. This assessment of Beaver Creek is a portion of the assessment of Big Spring Creek and three of its tributary streams: Cottonwood Creek, Beaver Creek and East Fork of Big Spring Creek. Big Spring Creek is a tributary to the Judith River and is located in Central Montana near Lewistown. Under Section 303(d) of the Clean Water Act, three of the above streams, Big Spring Creek, Cottonwood Creek and Beaver Creek, are listed on the 2002 Montana 303(d) List. Existing data on the East Fork of Big Spring Creek were insufficient for making a beneficial use support determination in 2002, and the stream was scheduled for reassessment. **Table 1-1** summarizes 303(d) status of the streams assessed in this report.

Table 1-1 ***303(d) Status of Beaver Creek and Selected Tributaries in 2002.***

Stream	Beneficial Uses Impacted	Probable Causes	Probable Sources
Big Spring Creek	Aquatic Life Cold Water Fishery	Fish Habitat Degradation Nutrients PCBs Riparian Degradation Sedimentation	Municipal Point Sources Agriculture Grazing Land Disposal Septic Systems Hydromodification Channelization
Cottonwood Creek	Aquatic Life Cold Water Fishery Drinking Water Supply Industrial Recreation	Dewatering Fish Habitat Degradation Flow Alteration Nutrients Organic Enrichment Riparian Degradation Sedimentation	Agriculture Grazing Hydromodification Habitat Modification Removal of Riparian Vegetation
Beaver Creek	Aquatic Life Cold Water Fishery Drinking Water Supply Recreation	Bank erosion Dewatering Fish habitat degradation Flow alteration Nutrients Riparian Degradation Sedimentation	Agriculture Grazing Habitat Modification Removal of Riparian Vegetation
East Fork of Big Spring Creek	Scheduled for Reassessment	Scheduled for Reassessment	Scheduled for Reassessment

According to the Montana Water Quality Act, the State of Montana must monitor the extent to which the state’s surface water bodies support legally designated beneficial uses. As part of this monitoring, the state must develop Total Maximum Daily Loads (TMDLs) and associated water quality restoration plans for Montana water bodies in which one or more pollutants impair designated beneficial uses. The Montana Department of Environmental Quality (MDEQ) will be developing a TMDL for Big Spring Creek Planning Area. The results of the remote assessment presented in this report were designed to provide technical assistance to the MDEQ Big Spring Creek TMDL Assessment (MDEQ Task Order No. 202104-03). A copy of MDEQ Task Order No. 202104-03 is provided as **Appendix A**.

2.0 METHODS

Black and white stereo aerial photography, 7.5-minute topographic maps and planimetric maps were used to delineate the target streams into relatively homogeneous reaches. Reach breaks were established using the following criteria: 1) at status boundaries as delineated by the applicable planimetric map, 2) at significant changes in channel slope, valley type, 3) at functional changes in riparian vegetation and 4) at the confluence of major tributary streams. Reach names and breaks were transcripted onto the topographic maps and aerial photos. **Table 2-1** provides a summary of the topographic and planimetric maps used for each target stream.

Table 2-1 ***Map Summary***

Stream	Topographic Map(s)	Planimetric Map(s)
Big Spring Creek	Danvers Spring Creek Junction Glengarry Lewistown Pike Creek	BLM Lewistown 1:100,000-scale planimetric map
Cottonwood Creek	Spring Creek Junction Glengarry West Fork Beaver Creek Castle Butte Jump Off Peak	BLM Lewistown 1:100,000-scale planimetric map
Beaver Creek	Glengarry West Fork Beaver Creek Castle Butte	Lewis and Clark National Forest Forest Visitors Map
E. Fork of Big Spring Creek	Heath Half Moon Canyon	BLM Big Snowy 1:100,000-scale planimetric map

Within each reach, aerial photography was used to characterize and assess several parameters (described below in **Section 2.1**) pertaining to channel and riparian vegetation condition for each target stream. The dates of the aerial photographs varied somewhat between the streams: aerial photo coverage from June 6, 1989 was used to assess Big Spring Creek; aerial photos taken on May 30, 1995 were used to assess the three target tributaries to Big Spring Creek. All aerial photographs were at a scale of 1:6,000. Data were entered into the *Watershed Condition Inventory Remote Data Collection Form* created by Land & Water Consulting and edited and approved by Pete Schade of the MDEQ**.** Completed data forms are included as **Appendix B**.

Each target stream was assessed from its mouth to its headwaters, with the exception of East Fork of Big Spring Creek where aerial photo coverage was not available for approximately the lower eight miles of the stream. Because of the lack of photo coverage these eight miles were not included in this assessment.

2.1 Assessment Parameters

The following parameters were included in the aerial photo assessment:

2.1.1 Reach Information

Reach Name: Consists of the first three letters of the target stream name followed by a number (e.g. COT14). Reaches are numbered consecutively from the stream's mouth to its headwaters.

Reach Length (ft): The linear length of the specified stream reach. Measured to the nearest foot using a digital planimeter and topographic map.

2.1.2 Riparian Vegetation Area

Buffer Width: Measured to the nearest 5 feet to a maximum of 50 feet. An average width of the riparian vegetation buffer adjacent to both sides of the stream in the delineated reach.

Vegetation Type (%): Occularly assessed from the aerial photos. Types included (within a 50' buffer): 1) Conifers and Deciduous Trees, 2) Woody Shrubs, 3) Grass/Sedge (groundcover), 4) Bare ground/Disturbed and 5) Impervious/Urban.

Vegetation Condition: This parameter was replaced by "Vegetation Impact Category", described below. The replacement was made to more accurately organize and compare the reaches. This parameter appears on the data collection forms, but no data were collected.

Degraded Riparian Vegetation: number of feet of stream bank (both sides) with human-impacts to riparian vegetation. Impacts included: 1) areas that had physically observable damaged riparian communities (e.g. trampled), 2) complete lack of riparian vegetation and 3) no woody vegetation observable on banks where such vegetation would be expected based on comparison with upstream/downstream reaches. Impacted riparian vegetation areas were transcribed onto topographic maps and impacted areas were measured to the nearest decimal foot with GIS. The percentage of the reach with degraded riparian vegetation was then calculated by the following formula:

(feet degraded riparian vegetation) / (feet of stream bank, both sides) = % of the reach impacted

Vegetation Impact Category: The reaches were ranked according to the level (% of reach) of impacts and assigned to an impact category according to the following criteria: 1) degraded riparian conditions along 50% or more of the reach indicates a **Highly Impacted** condition; 2) degraded riparian conditions along 25-49% of the reach indicates a **Moderately Impacted** condition; and 3) degraded riparian conditions along 1-24% of the reach indicates a **Lightly Impacted** to riparian vegetation condition. Only reaches with no observable impacts to riparian vegetation (% of reach impacted = 0) were ranked as **Not Impacted**.

2.1.3 Channel Condition

Sinuosity: Sinuosity = reach channel length / reach valley length (as measured from an aerial photo)

Valley Gradient or Slope (%): Gradient = change in elevation in feet / distance of elevation change in feet (measured between contour intervals from the topographic map)

Rosgen Type (Level 1): Stream channel classification based on channel slope, sinuosity, valley type, stream pattern and form (Rosgen, 1996).

Rosgen Type Potential (Level 1): Potential (future) Rosgen stream classification based on occular evidence of natural stream geomorphologic transition *or* evidence of a degraded stream condition that with improvement would have a different stream classification

Channel Degradation: Evidence of the following channel degradation characteristics on an aerial photo: 1) Rip rap, 2) Channelization, 3) Unstable Banks, 4) Severely Eroding Banks. Unstable banks were characterized as those with ocular evidence of light to moderate erosion, while severely eroding banks were characterized as those with evidence of wider scale bank slumping, mass wasting or bank failure.

Impacted channel areas were transcribed onto topographic maps and impacted areas were measured to the nearest decimal foot with GIS. The percentage of the reach with each of the above channel characteristics was then calculated by the following formula:

(feet of channel characteristic) / (feet of stream bank, both sides) = % of the reach impacted

Overall Channel Condition: This parameter was replaced by “Channel Impact Category”, described below. The replacement was made to more accurately organize and compare the reaches. This parameter appears on the data collection forms, but no data were collected.

Channel Impact Category: The reaches were ranked according to the cumulative score of *anthropogenic* impacts created by the summation of % of each reach in the four channel degradation parameters (rip rap, channelization, unstable banks, severely eroding banks): reaches with a cumulative score greater than 50 were labeled as **Highly Impacted;** reaches with a score of 25 to 49 were labeled as **Moderately Impacted**; reaches with a score of 1 to 24 were labeled as **Lightly Impacted**; reaches with a score of 0 were labeled as **Not Impacted**. In calculating the channel impact score, the eroding stream banks that appeared to result from naturally erodible bank terraces were removed so that only anthropogenic impacts were included.

Meander Cutoff Potential: Subjective rating of Low, Medium or High potential that a stream meander will be cut off in the future due to erosion/deposition.

2.1.4 General Characteristics

Reference Potential: Whether or not the reach could be considered *reference*, or a reach representing “ideal” or least impacted channel and vegetation characteristics

Land Use: Adjacent anthropogenic or natural land use characteristics that may be contributing to water quality impairment and/or bank instability. Land use comments were transcripted onto aerial photos.

3.0 IMPACT SUMMARY

3.1 Beaver Creek

This section presents a summary and analysis of selected riparian and channel condition variables. **Appendix B** presents a tabular summary of all of the data collected on Beaver Creek.

3.1.1 Riparian Vegetation Impacts

Table 3-1 provides a summary of selected characteristics of riparian vegetation on Beaver Creek. The majority of the reaches were classified as Highly and Moderately Impacted, indicating riparian degradation between 25 and 50 percent of the reach. Beaver Creek reaches that were ranked as Lightly or Not Impacted will be considered "Vegetation Reference Reaches" for the purposes of this assessment (**Section 4.0**).

Table 3-1 ***Riparian Vegetation Characteristics – Beaver Creek***

Reach	Total Bank Length (ft)	Buffer Width (ft)	Vegetation Type (% of reach)					Degraded Riparian Vegetation (%)	Vegetation Impact Category
			Con/Dec (%)	Woody Shrub (%)	Bare ground/ disturbed (%)	Grass/ Sedge (%)	Impervious/ Urban (%)		
BEA9	12638	15	20	20	0	60	0	83	Highly Impacted
BEA12	16704	10	5	20	0	75	0	80	Highly Impacted
BEA8	15788	15	5	35	0	60	0	79	Highly Impacted
BEA7	8282	10	5	30	5	60	0	78	Highly Impacted
BEA5	17234	15	5	60	0	35	0	69	Highly Impacted
BEA16	8490	15	25	25	0	50	0	65	Highly Impacted
BEA17	12170	15	30	20	0	50	0	65	Highly Impacted
BEA3	9804	20	30	40	0	25	5	57	Highly Impacted
BEA4	11218	30	55	20	0	20	5	51	Highly Impacted
BEA2	16234	10	5	20	5	70	0	45	Moderately Impacted
BEA18	5732	50	0	60	0	40	0	37	Moderately Impacted
BEA6	14234	35	5	75	0	20	0	35	Moderately Impacted
BEA11	14364	50	5	75	0	20	0	28	Moderately Impacted
BEA15	12794	25	30	30	0	40	0	28	Moderately Impacted
BEA10	15586	50	5	70	0	25	0	23	Lightly Impacted
BEA14	11184	>50	40	40	0	20	0	8	Lightly Impacted
BEA1	8844	>50	5	80	0	15	0	0	Not Impacted
BEA13	8418	50	10	75	0	15	0	0	Not Impacted
BEA19	39324	>50	75	15	0	10	0	0	Not Impacted

3.1.2 Stream Channel Characteristics

Table 3-2 provides a summary of selected stream channel characteristics of Beaver Creek. There were no Highly Impacted reaches with respect to channel condition; all reaches fell into the Moderately Impacted, Lightly Impacted or Not Impacted categories. Beaver Creek reaches that were ranked as Lightly or Not Impacted will be considered "Channel Reference Reaches" for the purposes of this assessment (**Section 4.0**). Note that the Cumulative Channel Impact Score is the sum of the four Channel Degradation Characteristics minus the portion of the eroding banks that were classified as natural erosion from unvegetated terraces.

Table 3-2 ***Stream Channel Characteristics – Beaver Creek***

Reach	Total Bank Length (ft)	Channel Degradation Characteristics (% of reach)				Minus (-) "Natural" Erosion	Cumulative Channel Impact Score	Channel Impact Category
		Rip rap	Channelized	Unstable Banks	Severely Eroding Banks			
BEA12	16704	1	0	37	8	0	46	Moderately Impacted
BEA9	12638	0	11	19	15	0	45	Moderately Impacted
BEA17	12170	0	0	35	2	0	37	Moderately Impacted
BEA16	8490	0	16	19	0	0	35	Moderately Impacted
BEA4	11218	3	11	11	4	0	29	Moderately Impacted
BEA3	9804	6	0	18	3	0	26	Moderately Impacted
BEA7	8282	0	0	11	9	0	20	Lightly Impacted
BEA8	15788	0	0	11	9	0	20	Lightly Impacted
BEA5	17234	0	2	12	4	0	17	Lightly Impacted
BEA2	16234	3	0	7	2	0	12	Lightly Impacted
BEA10	15586	0	0	7	5	0	12	Lightly Impacted
BEA6	14234	0	0	4	7	0	11	Lightly Impacted
BEA15	12794	0	0	10	0	0	10	Lightly Impacted
BEA18	5732	0	0	6	0	0	6	Lightly Impacted
BEA14	11184	0	0	5	0	0	5	Lightly Impacted
BEA11	14364	0	0	0	2	0	2	Lightly Impacted
BEA1	8844	0	0	0	0	0	0	Not Impacted
BEA13	8418	0	0	0	0	0	0	Not Impacted
BEA19	39324	0	0	0	0	0	0	Not Impacted

Table 3-3 provides a comparison of Vegetation and Channel Impact ratings, listed from the most highly impacted to the least impacted. In general, vegetation and channel conditions in each reach were within one impact category of one another, with the exceptions of BEA5, BEA7 and BEA8, where the vegetation was highly impacted but the channel only lightly impacted.

Table 3-3 ***Vegetation/ Channel Impact Comparison - Beaver Creek***

Reach	Vegetation Impact Category	Channel Impact Category	Reach	Vegetation Impact Category	Channel Impact Category	Reach	Vegetation Impact Category	Channel Impact Category
BEA3	Highly Impacted	Moderately Impacted	BEA7	Highly Impacted	Lightly Impacted	BEA10	Lightly Impacted	Lightly Impacted
BEA4	Highly Impacted	Moderately Impacted	BEA8	Highly Impacted	Lightly Impacted	BEA14	Lightly Impacted	Lightly Impacted
BEA9	Highly Impacted	Moderately Impacted	BEA2	Moderately Impacted	Lightly Impacted	BEA1	Not Impacted	Not Impacted
BEA12	Highly Impacted	Moderately Impacted	BEA6	Moderately Impacted	Lightly Impacted	BEA13	Not Impacted	Not Impacted
BEA16	Highly Impacted	Moderately Impacted	BEA11	Moderately Impacted	Lightly Impacted	BEA19	Not Impacted	Not Impacted
BEA17	Highly Impacted	Moderately Impacted	BEA15	Moderately Impacted	Lightly Impacted			
BEA5	Highly Impacted	Lightly Impacted	BEA18	Moderately Impacted	Lightly Impacted			

3.1.3 Previous Assessments

The National Resource Conservation Service (NRCS) performed a helicopter survey of several of the Big Spring Creek tributaries in 1995. Observations that could be compared with Land & Water's assessment of Beaver Creek are summarized below in **Table 3-4**.

Table 3-4 ***1995 Helicopter Survey (NRCS) - Beaver Creek***

Source	Channelization	"Entrenched/Eroding Banks/Active Erosion Site"	"Impacted/Absent Veg. Community"
1995 NRCS Survey	3,427	3,557	15,363
Land & Water Assessment	4,230	36,625 (Unstable Banks + Severely Eroding Banks)	105,960 (Degraded Riparian Vegetation)

All data are in feet
All data includes both natural and anthropogenic sources

In all three data categories presented in **Table 3-4**, Land & Water found higher levels of impact than were found in the NRCS helicopter survey. The reasons for the different findings are not clear, but probably result from the different methodologies employed in the two assessments. No information regarding the method used by the NRCS or how the agency defined vegetation impacts or eroding banks was located for this report.

4.0 DISCUSSION/RECOMMENDATIONS

4.1 Relationship of Riparian Vegetation Characteristics with Channel Erosion

Select riparian characteristics were compared to the total percentage of unstable and eroding banks in each reach in order to provide a quantitative estimate of the correlation between riparian vegetation and bank stability (**Table 4-1).** The combined % of unstable and eroding banks was sorted and divided in quartiles, and the data presented in Table 4-1 are presented separately for each of these quartiles. In general, erosion decreased as buffer width, tree cover and shrub cover increased, conforming to the expectation that woody vegetation stabilizes stream banks. Conversely, increased grass and sedge coverage was associated with increasing erosion.

Table 4-1 ***Comparison Between Riparian Vegetation Characteristics and Channel Erosion - Beaver Creek***

	Riparian Vegetation Characteristics						
Reach	**Buffer Width (ft)**	**Con/Dec (% of reach)**	**Woody Shrub (% of reach)**	**Bare ground/ disturbed (% of reach)**	**Grass/ Sedge (% of reach)**	**Impervious/ Urban (% of reach)**	**Combined Unstable/Eroding Banks (% of reach)**
BEA12	10	5	20	0	75	0	46
BEA17	15	30	20	0	50	0	37
BEA9	15	20	20	0	60	0	34
BEA3	20	30	40	0	25	5	21
BEA7	10	5	30	5	60	0	20
Averages Quartile 4	*14*	*18*	*26*	*1*	*54*	*1*	*32*
BEA8	15	5	35	0	60	0	20
BEA16	15	25	25	0	50	0	19
BEA5	15	5	60	0	35	0	16
BEA4	30	55	20	0	20	5	15
BEA10	50	5	70	0	25	0	12
Averages Quartile 3	*25*	*19*	*42*	*0*	*38*	*1*	*16*
BEA6	35	5	75	0	20	0	11
BEA15	25	30	30	0	40	0	10
BEA2	10	5	20	5	70	0	9
BEA18	50	0	60	0	40	0	6
BEA14	>50	40	40	0	20	0	5
Averages Quartile 2	*30*	*16*	*45*	*1*	*38*	*0*	*8*
BEA11	50	5	75	0	20	0	2
BEA1	>50	5	80	0	15	0	0
BEA13	50	10	75	0	15	0	0
BEA19	>50	75	15	0	10	0	0
Averages Quartile 1	*50*	*24*	*61*	*0*	*15*	*0*	*1*

4.2 Characteristics of Reference Reaches

Vegetation and Channel Reference Reaches were identified for Beaver Creek to provide a gauge for forming restoration targets. As was discussed in **Section 3.1.1** and **3.1.2**, reference reaches are those that were classified as Lightly or Not Impacted in the vegetation and channel condition assessments. Reaches in reference condition occurred throughout the three regions of Beaver Creek (upper, middle, and lower). A summary of the average characteristics of the reference reaches is presented for vegetation and channel conditions in **Table 4-2** and **4-3**, respectively.

Table 4-2 ***Vegetation Reference Reaches - Beaver Creek***

Location on Beaver Cr.	Reach	Coniferous/Deciduous (%)	Woody Shrub (%)	Degraded Riparian Vegetation (%)
Middle	BEA10	5	70	23
Upper	BEA14	40	40	8
Lower	BEA1	5	80	0
Upper	BEA13	10	75	0
Upper	BEA19	75	15	0
	averages	*27*	*56*	*6*
	TARGET	27% tree + 56% shrub = **≥ 83% tree/shrub types**		**Degraded Riparian Vegetation ≤ 6%**

Table 4-3 ***Channel Reference Reaches - Beaver Creek***

Location on Beaver Cr.	Reach	Channelization (%)	Unstable Banks (%)	Severely Eroding Banks (%)
Middle	BEA7	0	11	9
Middle	BEA8	0	11	9
Lower	BEA5	2	12	4
Lower	BEA2	0	7	2
Middle	BEA10	0	7	5
Lower	BEA6	0	4	7
Upper	BEA15	0	10	0
Upper	BEA18	0	6	0
Middle	BEA14	0	5	0
Middle	BEA11	0	0	2
Lower	BEA1	0	0	0
Upper	BEA13	0	0	0
Upper	BEA19	0	0	0
	averages	0	6	3
	TARGET	**Channelized 0%**	6% unstable + 3% severely eroding = **Eroding Banks ≤ 9%**	

4.3 Comparison of Reference Reaches with Highly Degraded Reaches

The target conditions derived in **Tables 4-2 and 4-3** above were compared to the conditions in the most degraded reaches on Beaver Creek. For Beaver Creek, the “most degraded” reaches were defined to be those in which the vegetation condition and/or the channel condition were rated as Highly Impacted (**Table 3-3**). These represent reaches of Beaver Creek that appear to be in the greatest need of restoration and where the largest potential reductions in sediment loading could be achieved. **Table 4-4** summarizes the most degraded reaches and describes their land use characteristics. **Table 4-5** compares the most degraded reaches to reference conditions.

Table 4-4 ***“Most Degraded” Reaches – Beaver Creek***

Reach	Location on Beaver Cr.	Vegetation Impact Category	Channel Impact Category	Land Use Characteristics
BEA3	Lower	Highly Impacted	Moderately Impacted	ranch on LB; extensive grazing; 2 bridges both with riprap; dirt roads; 1 agriculture field to within 20' of bank LB/RB
BEA4	Lower	Highly Impacted	Moderately Impacted	fields to edge, LB/RB; 2 bridges; riprap
BEA9	Middle	Highly Impacted	Moderately Impacted	ranch; fields to edge; RB/LB; 1 fiord; 1 bridge; road and stock access near ranch facility
BEA12	Middle	Highly Impacted	Moderately Impacted	grazing; ranch on LB
BEA16	Upper	Highly Impacted	Moderately Impacted	grazing; stock access
BEA17	Upper	Highly Impacted	Moderately Impacted	2 bridges; grazing
BEA5	Lower	Highly Impacted	Lightly Impacted	channelized ~ 300' road; 1 bridge; grazing
BEA7	Middle	Highly Impacted	Lightly Impacted	field to edge RB/LB; 2 bridges; ranch
BEA8	Middle	Highly Impacted	Lightly Impacted	creek runs through agriculture fields with little to no buffer; 1 bridge

LB = left bank
RB = right bank

Table 4-5 ***"Most Degraded" Reach Target Characteristic Values – Beaver Creek***

	Target Characteristic	*Target Value (%)*	BEA3	BEA4	BEA9	BEA12	BEA16	BEA17	BEA5	BEA7	BEA8
Vegetation	Tree/shrub Types	*≥ 83*	70	75	40	25	50	50	65	35	40
	Degraded Riparian Vegetation	*≤ 6*	57	51	83	80	65	65	69	78	79
Channel	Channelized	*0*	0	11	11	0	16	0	2	0	0
	Eroding Banks	*≤ 9*	21	15	34	45	19	37	16	20	20

4.4 Restoration Focus Areas

4.4.1 Previous Restoration Activities

In 1995, the NRCS conducted several restoration projects on privately owned and state land on Beaver Creek. **Table 4-6** describes the restoration projects that were detailed in the NRCS study. There was no information available regarding the success of these projects or describing whether the riparian management was continued past the 1995 study.

Table 4-6 ***1995 NRCS Restoration Projects***

Reach	Owner	Riparian Fencing (ft)	Channel Improved* (ft)	Stream/Riparian Improved* (ft)	Off-site Watering Locations Provided	Comments
BEA16/ BEA17	Walt and Gail Regli	None	1,930	3,200	One	Complete

*No information was provided as to the improvement technique.

4.4.2 Restoration Priorities

For each of the "most degraded" reaches of Beaver Creek described in **Section 4.3**, this section summarizes the major impacts observed during the air photo assessment. Because of their heavily impacted condition, these reaches represent the areas most likely in need of restoration.

BEA3 - The primary impact was to riparian vegetation; 57% of the riparian vegetation community was degraded. The tree/shrub cover was within 13% of the target value. 21% of the channel was unstable or eroding, also within 13% of the target value for eroding banks. A ranch with evidence of grazing and fields/roads to within 20 feet of the bank edge was observed. Proper riparian function may be improved by providing off-site watering locations coupled with riparian fencing.

BEA4 – This reach was similar in characteristics to the adjacent downstream reach, BEA3 (above). The primary impact was to riparian vegetation; 51% of the riparian vegetation community was degraded. The tree/shrub cover was within 8% of the target value. 11% of the channel was unstable or eroding, within 6% of the target value for eroding banks. 11% of the channel had been channelized. Agricultural fields with limited streamside buffers were observed and 3% of the banks are stabilized with riprap.

BEA9 - The primary impact was to riparian vegetation; 83% of the riparian vegetation community was degraded. The tree/shrub cover was half of the target value. 34% of the channel was unstable or eroding, over three times the target value for eroding banks. 11% of the channel had been channelized. A ranch with fields to the bank edge and concentrated stock access was observed.

BEA12 - The primary impact was to riparian vegetation; 80% of the riparian vegetation community was degraded. The tree/shrub cover was approximately 25% of the target value. 45% of the channel was unstable or eroding, over four times the target value for eroding banks. A ranch with evidence of livestock grazing was observed.

BEA16 - The channel condition was relatively good; the percentage of unstable or eroding banks was within 10% of the target value and a small amount of the reach was channelized (16%). The primary impacts to the reach were to the riparian vegetation: 65% of the riparian vegetation was degraded. The tree/shrub cover was less than approximately 35% of the target value. Evidence of grazing and concentrated stock access was observed.

According to the 1995 NRCS data, between BEA16 and BEA17, 1,930 feet of the channel and 3,200 feet of the stream/riparian area was improved in 1995, although not information was provided to describe how these improvements were made. One off-site watering location was installed.

BEA17 – The riparian conditions were the same as in the adjacent downstream reach, BEA16 (above). 65% of the riparian vegetation was degraded. The tree/shrub cover was less than approximately 35% of the target value. 37% of the channel was unstable or eroding. Evidence of grazing was observed.

According to the 1995 NRCS data, between BEA16 and BEA17, 1,930 feet of the channel and 3,200 feet of the stream/riparian area was improved in 1995, although no information was provided to describe how these improvements were made. One off-site watering location was installed.

BEA5 - The primary impact was to riparian vegetation; 69% of the riparian vegetation community was degraded. The tree/shrub cover was approximately 20% below the target value. The channel condition was relatively good; the percentage of unstable or eroding banks was within 7% of the target value and a small amount of the reach was channelized (2%). Evidence of grazing was observed.

BEA7 - The primary impact was to riparian vegetation; 78% of the riparian vegetation community was degraded. The tree/shrub cover was nearly 50% below the target value. 20% of the channel was unstable or eroding, within 9% the target value for eroding banks. A ranch with evidence of grazing and agricultural fields to the bank edge was observed.

BEA8 – This reach was similar in characteristics to the adjacent downstream reach, BEA7 (above). The primary impact was to riparian vegetation; 79% of the riparian vegetation community was degraded. The tree/shrub cover was 50% of the target value. 20% of the channel was unstable or eroding, within 9% the target value for eroding banks. The stream ran through agricultural fields that were to the bank edge.

5.0 CONCLUSIONS

Degraded riparian vegetation appeared to be the most common impact to Beaver Creek and the greatest potential cause of increased sediment input. The primary sources of vegetation impacts were related to land use: agriculture and grazing appeared to have had significant impacts to riparian communities.

On the majority of the reaches, the vegetation condition was classified as Highly or Moderately Impacted, indicating that on the majority of the reaches, greater than 25% of the riparian vegetation was degraded. There were no Highly Impacted reaches with respect to channel condition; all reaches fell into the Moderately Impacted, Lightly Impacted or Not Impacted categories

Select riparian characteristics were compared to the total percentage of unstable and eroding banks in each reach in order to provide a quantitative estimate of the correlation between riparian vegetation and bank stability. Few if any connections between vegetation condition and bank stability were obvious from the comparison, suggesting a more complicated set of circumstances controls bank stability on Beaver Creek.

In general, the proportion of stream banks in unstable condition decreased as buffer width, tree cover and shrub cover increased, suggesting that woody vegetation is key to maintaining bank stability on Beaver Creek. As is presented below (**Table 5-1**), degraded riparian vegetation was observed along 44% of the total bank length of Beaver Creek, and 15% of the streambanks were rated as either unstable (11%) or severely eroding (4%). Only 1% of the banks have been stabilized with riprap and only 2% of the stream has been channelized, indicating that few permanent "hard" alterations have been made to Beaver Creek and suggesting that restoration potential is very good.

Table 5-1 ***Summary of Degradation Statistics***

Degraded Riparian Vegetation	Riprap	Channelization	Unstable Banks	Severely Eroding Banks
44%	1%	2%	11%	4%

The air photo assessment that was conducted for this report was not at a scale that allows for detailed site-specific restoration recommendations. However, the following general recommendations could guide restoration efforts, particularly in those reaches identified in **Section 4.3** as “most degraded” and thus most in need of restoration:

- Providing at least a 50 foot vegetation buffer between Beaver Creek and fields/roads;
- Improving proper riparian function by providing off-site watering locations coupled with riparian fencing;
- Enhancing the tree and woody shrub community where there is potential to aid in erosion reduction or maintenance of bank stability;
- Restructuring of the channelized portions of the reach to a more sinuous condition to aid in reducing stream flow velocities; and
- Mechanical bank stabilization where possible.

APPENDIX D

BIG SPRING CREEK TMDL TECHNICAL ASSISTANCE AERIAL PHOTOGRAPHY ASSESSMENT (FINAL)

Cottonwood Creek

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December 2003

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FIGURES AND TABLES

FIGURES

All Figures provided separately.

TABLES

1.0 INTRODUCTION

This report presents the results of a remote assessment of channel and riparian vegetation conditions that was conducted for Cottonwood Creek in central Montana. This assessment of Cottonwood Creek is a portion of the assessment of Big Spring Creek and three of its tributary streams: Cottonwood Creek, Beaver Creek and East Fork of Big Spring Creek. Big Spring Creek is a tributary to the Judith River and is located in Central Montana near Lewistown. Under Section 303(d) of the Clean Water Act, three of the above streams, Big Spring Creek, Cottonwood Creek and Beaver Creek, are listed on the 2002 Montana 303(d) List. Existing data on the East Fork of Big Spring Creek were insufficient for making a beneficial use support determination in 2002, and the stream was scheduled for reassessment. **Table 1-1** summarizes 303(d) status of the streams assessed in this report.

Table 1-1 ***303(d) Status of Cottonwood Creek and Selected Tributaries in 2002.***

Stream	Beneficial Uses Impacted	Probable Causes	Probable Sources
Big Spring Creek	Aquatic Life Cold Water Fishery	Fish Habitat Degradation Nutrients PCBs Riparian Degradation Sedimentation	Municipal Point Sources Agriculture Grazing Land Disposal Septic Systems Hydromodification Channelization
Cottonwood Creek	Aquatic Life Cold Water Fishery Drinking Water Supply Industrial Recreation	Dewatering Fish Habitat Degradation Flow Alteration Nutrients Organic Enrichment Riparian Degradation Sedimentation	Agriculture Grazing Hydromodification Habitat Modification Removal of Riparian Vegetation
Beaver Creek	Aquatic Life Cold Water Fishery Drinking Water Supply Recreation	Bank erosion Dewatering Fish habitat degradation Flow alteration Nutrients Riparian Degradation Sedimentation	Agriculture Grazing Habitat Modification Removal of Riparian Vegetation
East Fork of Big Spring Creek	Scheduled for Reassessment	Scheduled for Reassessment	Scheduled for Reassessment

According to the Montana Water Quality Act, the State of Montana must monitor the extent to which the state's surface water bodies support legally designated beneficial uses. As part of this monitoring, the state must develop Total Maximum Daily Loads (TMDLs) and associated water quality restoration plans for Montana water bodies in which one or more pollutants impair designated beneficial uses. The Montana Department of Environmental Quality (MDEQ) will be developing a TMDL for Big Spring Creek Planning Area. The results of the remote assessment presented in this report were designed to provide technical assistance to the MDEQ Big Spring Creek TMDL Assessment (MDEQ Task Order No. 202104-03). A copy of MDEQ Task Order No. 202104-03 is provided as **Appendix A**.

2.0 METHODS

Black and white stereo aerial photography, 7.5-minute topographic maps and planimetric maps were used to delineate the target streams into relatively homogeneous reaches. Reach breaks were established using the following criteria: 1) at status boundaries as delineated by the applicable planimetric map, 2) at significant changes in channel slope, valley type, 3) at functional changes in riparian vegetation and 4) at the confluence of major tributary streams. Reach names and breaks were transcripted onto the topographic maps and aerial photos. **Table 2-1** provides a summary of the topographic and planimetric maps used for each target stream.

Table 2-1 ***Map Summary***

Stream	Topographic Map(s)	Planimetric Map(s)
Big Spring Creek	Danvers Spring Creek Junction Glengarry Lewistown Pike Creek	BLM Lewistown 1:100,000-scale planimetric map
Cottonwood Creek	Spring Creek Junction Glengarry West Fork Beaver Creek Castle Butte Jump Off Peak	BLM Lewistown 1:100,000-scale planimetric map
Beaver Creek	Glengarry West Fork Beaver Creek Castle Butte	Lewis and Clark National Forest Forest Visitors Map
E. Fork of Big Spring Creek	Heath Half Moon Canyon	BLM Big Snowy 1:100,000-scale planimetric map

Within each reach, aerial photography was used to characterize and assess several parameters (described below in **Section 2.1**) pertaining to channel and riparian vegetation condition for each target stream. The dates of the aerial photographs varied somewhat between the streams: aerial photo coverage from June 6, 1989 was used to assess Big Spring Creek; aerial photos taken on May 30, 1995 were used to assess the three target tributaries to Big Spring Creek. All aerial photographs were at a scale of 1:6,000. Data were entered into the *Watershed Condition Inventory Remote Data Collection Form* created by Land & Water Consulting and edited and approved by Pete Schade of the MDEQ**.** Completed data forms are included as **Appendix B**.

Each target stream was assessed from its mouth to its headwaters, with the exception of East Fork of Big Spring Creek where aerial photo coverage was not available for approximately the lower eight miles of the stream. Because of the lack of photo coverage these eight miles were not included in this assessment.

2.1 Assessment Parameters

The following parameters were included in the aerial photo assessment:

2.1.1 Reach Information

Reach Name: Consists of the first three letters of the target stream name followed by a number (e.g. COT14). Reaches are numbered consecutively from the stream's mouth to its headwaters.

Reach Length (ft): The linear length of the specified stream reach. Measured to the nearest foot using a digital planimeter and topographic map.

2.1.2 Riparian Vegetation Area

Buffer Width: Measured to the nearest 5 feet to a maximum of 50 feet. An average width of the riparian vegetation buffer adjacent to both sides of the stream in the delineated reach.

Vegetation Type (%): Occularly assessed from the aerial photos. Types included (within a 50' buffer): 1) Conifers and Deciduous Trees, 2) Woody Shrubs, 3) Grass/Sedge (groundcover), 4) Bare ground/Disturbed and 5) Impervious/Urban.

Vegetation Condition: This parameter was replaced by "Vegetation Impact Category", described below. The replacement was made to more accurately organize and compare the reaches. This parameter appears on the data collection forms, but no data were collected.

Degraded Riparian Vegetation: number of feet of stream bank (both sides) with human-impacts to riparian vegetation. Impacts included: 1) areas that had physically observable damaged riparian communities (e.g. trampled), 2) complete lack of riparian vegetation and 3) no woody vegetation observable on banks where such vegetation would be expected based on comparison with upstream/downstream reaches. Impacted riparian vegetation areas were transcribed onto topographic maps and impacted areas were measured to the nearest decimal foot with GIS. The percentage of the reach with degraded riparian vegetation was then calculated by the following formula:

(feet degraded riparian vegetation) / (feet of stream bank, both sides) = % of the reach impacted

Vegetation Impact Category: The reaches were ranked according to the level (% of reach) of impacts and assigned to an impact category according to the following criteria: 1) degraded riparian conditions along 50% or more of the reach indicates a **Highly Impacted** condition; 2) degraded riparian conditions along 25-49% of the reach indicates a **Moderately Impacted** condition; and 3) degraded riparian conditions along 1-24% of the reach indicates a **Lightly Impacted** to riparian vegetation condition. Only reaches with no observable impacts to riparian vegetation (% of reach impacted = 0) were ranked as **Not Impacted**.

2.1.3 Channel Condition

Sinuosity: Sinuosity = reach channel length / reach valley length (as measured from an aerial photo)

Valley Gradient or Slope (%): Gradient = change in elevation in feet / distance of elevation change in feet (measured between contour intervals from the topographic map)

Rosgen Type (Level 1): Stream channel classification based on channel slope, sinuosity, valley type, stream pattern and form (Rosgen, 1996).

Rosgen Type Potential (Level 1): Potential (future) Rosgen stream classification based on occular evidence of natural stream geomorphologic transition *or* evidence of a degraded stream condition that with improvement would have a different stream classification

Channel Degradation: Evidence of the following channel degradation characteristics on an aerial photo: 1) Rip rap, 2) Channelization, 3) Unstable Banks, 4) Severely Eroding Banks. Unstable banks were characterized as those with ocular evidence of light to moderate erosion, while severely eroding banks were characterized as those with evidence of wider scale bank slumping, mass wasting or bank failure.

Impacted channel areas were transcribed onto topographic maps and impacted areas were measured to the nearest decimal foot with GIS. The percentage of the reach with each of the above channel characteristics was then calculated by the following formula:

(feet of channel characteristic) / (feet of stream bank, both sides) = % of the reach impacted

Overall Channel Condition: This parameter was replaced by “Channel Impact Category”, described below. The replacement was made to more accurately organize and compare the reaches. This parameter appears on the data collection forms, but no data were collected.

Channel Impact Category: The reaches were ranked according to the cumulative score of *anthropogenic* impacts created by the summation of % of each reach in the four channel degradation parameters (rip rap, channelization, unstable banks, severely eroding banks): reaches with a cumulative score greater than 50 were labeled as **Highly Impacted;** reaches with a score of 25 to 49 were labeled as **Moderately Impacted**; reaches with a score of 1 to 24 were labeled as **Lightly Impacted**; reaches with a score of 0 were labeled as **Not Impacted**. In calculating the channel impact score, the eroding stream banks that appeared to result from naturally erodible bank terraces were removed so that only anthropogenic impacts were included.

Meander Cutoff Potential: Subjective rating of Low, Medium or High potential that a stream meander will be cut off in the future due to erosion/deposition.

2.1.4 General Characteristics

Reference Potential: Whether or not the reach could be considered *reference*, or a reach representing “ideal” or least impacted channel and vegetation characteristics

Land Use: Adjacent anthropogenic or natural land use characteristics that may be contributing to water quality impairment and/or bank instability. Land use comments were transcripted onto aerial photos.

3.0 IMPACT SUMMARY

3.1 Cottonwood Creek

This section presents a summary and analysis of selected riparian and channel condition variables. **Appendix B** presents a tabular summary of all of the data collected on Cottonwood Creek.

3.1.1 Riparian Vegetation Impacts

Table 3-1 provides a summary of selected characteristics of riparian vegetation on Cottonwood Creek. The majority of reaches were classified as either Moderately Impacted or Lightly Impacted. Only two reaches (COT 21 and COT 20) were classified as Highly Impacted, indicating that 50% or more of the riparian vegetation was significantly impacted by human activities on these two reaches. Cottonwood Creek reaches that were ranked as Lightly or Not Impacted will be considered "Vegetation Reference Reaches" for the purposes of this assessment (**Section 4.0**).

Table 3-1 ***Riparian Vegetation Characteristics – Cottonwood Creek***

Reach	Buffer Width (ft)	Total Bank Length (ft)	Vegetation Types (% of reach)					Degraded Riparian Vegetation (% of reach)	Vegetation Impact Category
			Con/Dec	Woody Shrub	Bare ground/ disturbed	Grass/ Sedge	Impervious/ Urban		
COT21	10	6718	10	50	20	20	0	69	Highly Impacted
COT20	20	8710	20	40	10	30	0	61	Highly Impacted
COT23	35	9680	50	0	5	45	0	49	Moderately Impacted
COT18	30	9622	40	30	5	25	0	40	Moderately Impacted
COT27	50	7150	20	50	20	10	0	39	Moderately Impacted
COT6	35	14578	50	40	0	10	0	37	Moderately Impacted
COT17	50	7136	50	30	0	20	0	36	Moderately Impacted
COT9	15	9082	40	20	0	40	0	35	Moderately Impacted
COT15	50	13700	50	25	5	20	0	33	Moderately Impacted
COT7	>50	17076	30	50	0	20	0	30	Moderately Impacted
COT28	40	9028	40	30	0	30	0	30	Moderately Impacted
COT14	50	8956	50	30	10	10	0	29	Moderately Impacted
COT24	50	9602	40	35	10	10	5	27	Moderately Impacted
COT2	15	16972	30	20	0	50	0	26	Moderately Impacted
COT3	20	14240	10	30	0	60	0	25	Moderately Impacted
COT4	30	17006	20	50	0	30	0	25	Moderately Impacted
COT25	35	9890	40	50	0	10	0	23	Lightly Impacted
COT19	>50	15164	15	70	5	10	0	18	Lightly Impacted
COT1	>50	15194	20	60	0	20	0	18	Lightly Impacted
COT16	50	13958	50	30	0	20	0	18	Lightly Impacted
COT13	>50	13306	50	30	0	20	0	16	Lightly Impacted
COT8	>50	11168	30	50	0	20	0	14	Lightly Impacted
COT11	>50	12514	60	20	0	20	0	14	Lightly Impacted
COT22	50	14748	40	40	10	10	0	13	Lightly Impacted
COT10	>50	18926	50	30	0	10	10	5	Lightly Impacted
COT12	>50	17240	70	15	0	15	0	4	Lightly Impacted
COT26	>50	9926	45	35	0	20	0	2	Lightly Impacted
COT5	>50	11896	30	60	0	10	0	0	Not Impacted
COT29	>50	14206	70	15	0	15	0	0	Not Impacted
COT30	>50	14832	100	0	0	0	0	0	Not Impacted

3.1.2 Stream Channel Characteristics

Table 3-2 provides a summary of selected stream channel characteristics of Cottonwood Creek. As was the case with the riparian vegetation, most reaches fell into the Moderately Impacted or Lightly Impacted categories. Only one reach, COT1, was rated as Highly Impacted. Cottonwood Creek reaches that were ranked as Lightly or Not Impacted to the stream channel will be considered "Channel Reference Reaches" for the purposes of this assessment (**Section 4.0**). Note that the Cumulative Channel Impact Score is the sum of the four Channel Degradation Characteristics minus the portion of the eroding banks that were classified as natural erosion from unvegetated terraces.

Table 3-2 ***Stream Channel Characteristics – Cottonwood Creek***

Reach	Total Bank Length (ft)	Channel Degradation (% of reach)				Minus (-) "Natural" Erosion (%)	Total Cumulative Channel Impact Score	Channel Impact Category
		Rip rap	Channelized	Unstable Banks	Severely Eroding Banks			
COT1	15164	0	22	12	5	5	34	Highly Impacted*
COT23	9680	0	0	22	20	0	42	Moderately Impacted
COT20	8710	0	0	32	3	0	35	Moderately Impacted
COT9	9082	0	0	16	18	0	34	Moderately Impacted
COT25	9890	0	0	33	0	0	33	Moderately Impacted
COT24	9602	0	0	15	16	0	31	Moderately Impacted
COT27	7150	0	0	30	0	0	30	Moderately Impacted
COT14	8956	0	0	2	27	0	29	Moderately Impacted
COT6	14578	0	0	9	14	1	22	Lightly Impacted
COT17	7136	0	0	22	0	0	22	Lightly Impacted
COT18	9622	0	0	14	9	3	20	Lightly Impacted
COT19	13958	0	0	15	3	0	18	Lightly Impacted
COT8	11168	4	0	9	6	3	16	Lightly Impacted
COT16	15194	0	0	10	3	0	13	Lightly Impacted
COT2	16972	0	0	12	6	6	12	Lightly Impacted
COT21	6718	0	0	11	0	0	11	Lightly Impacted
COT22	14748	0	0	5	5	0	10	Lightly Impacted
COT13	12514	0	0	6	6	3	9	Lightly Impacted
COT11	13306	0	0	7	6	4	9	Lightly Impacted
COT10	18926	0	0	5	6	5	6	Lightly Impacted
COT15	14240	1	0	4	0	0	5	Lightly Impacted
COT28	13700	0	0	5	0	0	5	Lightly Impacted
COT3	9028	0	0	2	4	1	5	Lightly Impacted
COT4	17006	0	0	2	13	11	4	Lightly Impacted
COT12	17240	0	0	4	0	0	4	Lightly Impacted
COT7	17076	0	0	7	3	3	3	Lightly Impacted
COT26	11896	0	0	0	0	0	0	Not Impacted
COT29	9926	0	0	0	0	0	0	Not Impacted
COT30	14206	0	0	0	0	0	0	Not Impacted
COT5	14832	0	0	0	1	1	0	Not Impacted

* Downgraded to Highly Impacted due to 22% channelization of the reach

Table 3-3 provides a comparison of Vegetation and Channel Impact ratings, listed from the most highly impacted to the least impacted. In general, vegetation and channel conditions in each reach were within on impact category of one another, with the exception of COT21, where the vegetation was highly impacted but the channel only lightly impacted, and COT1, where the vegetation was lightly impacted but the channel was highly impacted.

Table 3-3 ***Vegetation/Channel Impact Comparison - Cottonwood Creek***

Reach	Vegetation Impact Category	Channel Impact Category	Reach	Vegetation Impact Category	Channel Impact Category	Reach	Vegetation Impact Category	Channel Impact Category
COT20	Highly Impacted	Moderately Impacted	COT4	Moderately Impacted	Lightly Impacted	COT11	Lightly Impacted	Lightly Impacted
COT21	Highly Impacted	Lightly Impacted	COT6	Moderately Impacted	Lightly Impacted	COT12	Lightly Impacted	Lightly Impacted
COT1	Lightly Impacted	Highly Impacted	COT7	Moderately Impacted	Lightly Impacted	COT13	Lightly Impacted	Lightly Impacted
COT9	Moderately Impacted	Moderately Impacted	COT15	Moderately Impacted	Lightly Impacted	COT16	Lightly Impacted	Lightly Impacted
COT14	Moderately Impacted	Moderately Impacted	COT17	Moderately Impacted	Lightly Impacted	COT19	Lightly Impacted	Lightly Impacted
COT23	Moderately Impacted	Moderately Impacted	COT18	Moderately Impacted	Lightly Impacted	COT22	Lightly Impacted	Lightly Impacted
COT24	Moderately Impacted	Moderately Impacted	COT28	Moderately Impacted	Lightly Impacted	COT26	Lightly Impacted	Not Impacted
COT27	Moderately Impacted	Moderately Impacted	COT25	Lightly Impacted	Moderately Impacted	COT29	Not Impacted	Not Impacted
COT2	Moderately Impacted	Lightly Impacted	COT8	Lightly Impacted	Lightly Impacted	COT30	Not Impacted	Not Impacted
COT3	Moderately Impacted	Lightly Impacted	COT10	Lightly Impacted	Lightly Impacted	COT5	Not Impacted	Not Impacted

3.1.3 Previous Assessments

The Natural Resource Conservation Service (NRCS) conducted a helicopter survey of several of the Big Spring Creek tributaries in 1995. Observations that could be compared with Land & Water's assessment of Cottonwood Creek are summarized below in **Table 3-4**.

Table 3-4 ***1995 Helicopter Survey (NRCS) - Cottonwood Creek (feet)***

Source	Channelization	"Entrenched/Eroding Banks/Active Erosion Site"	"Impacted/Absent Veg. Community"
1995 NRCS Survey	2,977	22,805	31,283
Land & Water Assessment	3,457	54,364 (Unstable Banks + Severely Eroding Banks)	81,585 (Degraded Riparian Vegetation)

Includes both natural and anthropogenic sources

In all three data categories presented in **Table 3-4**, Land & Water found higher levels of impact than were found in the NRCS helicopter survey. The reasons for the different findings are not clear, but probably result from the different methodologies employed in the two assessments. No information regarding the method used by the NRCS or how the agency defined vegetation impacts or eroding banks was located for this report.

4.0 DISCUSSION/RECOMMENDATIONS

4.1 Relationship of Riparian Vegetation Characteristics with Channel Erosion

Select riparian characteristics were compared to the total percentage of unstable and eroding banks in each reach in order to provide a qualitative estimate of the correlation between riparian vegetation and bank stability (**Table 4-1).** The combined % of unstable and eroding banks was sorted and divided in quartiles, and the data presented in Table 4-1 are presented separately for each of these quartiles. Few, if any, obvious connections between vegetation condition and bank stability are obvious from this comparison, suggesting a more complicated set of circumstances controls bank stability in Cottonwood Creek.

Table 4-1 Comparison Between Riparian Vegetation Characteristics and Channel Erosion - Cottonwood Creek

	Riparian Vegetation Characteristics						
Reach	**Buffer Width (ft)**	**Con/Dec(% of reach)**	**Woody Shrub (% of reach)**	**Bare ground/ disturbed (%of reach)**	**Grass/ Sedge (% of reach)**	**Impervious/ Urban(%of reach)**	**Combined Unstable/Eroding Banks (% of reach)**
COT23	35	50	0	5	45	0	42
COT20	20	20	40	10	30	0	35
COT9	15	40	20	0	40	0	34
COT25	35	40	50	0	10	0	33
COT24	50	40	35	10	10	5	31
COT27	50	20	50	20	10	0	30
COT14	50	50	30	10	10	0	29
COT6	35	50	40	0	10	0	23
Averages Quartile 4	36	39	33	7	21	1	32
COT17	50	50	30	0	20	0	22
COT18	30	40	30	5	25	0	22
COT2	15	30	20	0	50	0	18
COT19	>50	15	70	5	10	0	18
COT1	>50	20	60	0	20	0	17
COT4	30	20	50	0	30	0	15
COT8	>50	30	50	0	20	0	15
COT13	>50	50	30	0	20	0	13
Averages Quartile 3	43	32	43	1	24	0	18
COT16	50	50	30	0	20	0	13
COT11	>50	60	20	0	20	0	12
COT10	>50	50	30	0	10	10	11
COT21	10	10	50	20	20	0	11
COT7	>50	30	50	0	20	0	10
COT22	50	40	40	10	10	0	10
COT3	20	10	30	0	60	0	6
Averages Quartile 2	35	36	36	4	23	1	10

Table 4-1 Comparison Between Riparian Vegetation Characteristics and Channel Erosion - Cottonwood Creek (continued)

	Riparian Vegetation Characteristics						
Reach	**Buffer Width (ft)**	**Con/Dec(% of reach)**	**Woody Shrub (% of reach)**	**Bare ground/ disturbed (%of reach)**	**Grass/ Sedge (% of reach)**	**Impervious/ Urban(%of reach)**	**Combined Unstable/Eroding Banks (% of reach)**
COT28	40	40	30	0	30	0	5
COT12	>50	70	15	0	15	0	4
COT15	50	50	25	5	20	0	4
COT5	>50	30	60	0	10	0	1
COT26	>50	45	35	0	20	0	0
COT29	>50	70	15	0	15	0	0
COT30	>50	100	0	0	0	0	0
Averages Quartile 1	50	58	26	1	16	0	2

4.2 Characteristics of Reference Reaches

Vegetation and Channel Reference Reaches were identified for Cottonwood Creek to provide a gauge for forming restoration targets. As was discussed in **Section 3.1.1** and **3.1.2**, reference reaches are those that were classified as Lightly or Not Impacted in the vegetation and channel condition assessments. The reference reaches occur throughout the three regions of Cottonwood Creek (upper, middle, and lower). A summary of the average characteristics of the reference reaches is presented for vegetation and channel conditions in **Table 4-2** and **4-3**, respectively.

Table 4-2 ***Vegetation Reference Reaches - Cottonwood Creek***

Location on Cottonwood Cr.	**Reach**	**Coniferous/Deciduous (%)**	**Woody Shrub (%)**	**Degraded Riparian Vegetation (%)**
Upper	COT25	40	50	23
Middle	COT19	15	70	18
Lower	COT1	20	60	18
Middle	COT16	50	30	18
Middle	COT13	50	30	16
Lower	COT8	30	50	14
Middle	COT11	60	20	14
Upper	COT22	40	40	13
Lower	COT10	50	30	5
Middle	COT12	70	15	4
Upper	COT26	45	35	2
Lower	COT5	30	60	0
Upper	COT29	70	15	0
Upper	COT30	100	0	0
averages		*48*	*36*	*10*
	TARGET	48% tree + 36% shrub = **≥ 84% tree/shrub types**		**Degraded Riparian Vegetation ≤ 10%**

Table 4-3 ***Channel Reference Reaches - Cottonwood Creek***

Reach	Location on Cottonwood Cr.	Channelization (%)	Unstable Banks (%)	Severely Eroding Banks (%)
COT6	Lower	0	9	14
COT17	Middle	0	22	0
COT18	Middle	0	14	9
COT19	Middle	0	15	3
COT8	Lower	0	9	6
COT16	Middle	0	10	3
COT2	Lower	0	12	6
COT21	Upper	0	11	0
COT22	Upper	0	5	5
COT13	Middle	0	6	6
COT11	Middle	0	7	6
COT10	Lower	0	5	6
COT15	Middle	0	4	0
COT28	Upper	0	5	0
COT3	Lower	0	2	4
COT4	Lower	0	2	13
COT12	Middle	0	4	0
COT7	Lower	0	7	3
COT26	Upper	0	0	0
COT29	Upper	0	0	0
COT30	Upper	0	0	0
COT5	Lower	0	0	1
	averages	0	7	4
	TARGET	**Channelized 0%**	7% unstable _4% severely eroding = **Eroding Banks ≤ 11%**	

4.3 Comparison of Reference Reaches with Highly Degraded Reaches

The target conditions derived in **Tables 4-2 and 4-3** above were compared to the conditions in the most degraded reaches on Cottonwood Creek. For Cottonwood Creek, the "most degraded" reaches were defined to be those in which 1) the vegetation conditions or the channel condition were rated as Highly Impacted; and/or 2) reaches in which both categories scored as Moderately Impacted (**Table 3-3**). These represent reaches of Cottonwood Creek that appear to be in the greatest need of restoration and where the largest potential reductions in sediment loading could be achieved. **Table 4-4** summarizes the most degraded reaches and describes their land use characteristics. **Table 4-5** compares the most degraded reaches to reference conditions.

Table 4-4 ***"Most Degraded" Reaches – Cottonwood Creek***

Reach	**Location on Big Spring Cr.**	**Vegetation Impact Category**	**Channel Impact Category**	**Land Use Characteristics**
COT20	Middle	Highly Impacted	Moderately Impacted	grazing; concentrated stock access points; fiord
COT21	Middle	Highly Impacted	Lightly Impacted	numerous fiords; concentrated stock access points; grazing
COT1	Lower	Lightly Impacted	Highly Impacted	ranch; fiord; floodplain is fenced off
COT9	Lower	Moderately Impacted	Moderately Impacted	grazing; agriculture fields to bank
COT14	Middle	Moderately Impacted	Moderately Impacted	grazing; agriculture fields to bank
COT23	Upper	Moderately Impacted	Moderately Impacted	fiord; grazing; stock access
COT24	Upper	Moderately Impacted	Moderately Impacted	ranch on bank; grazing; road adjacent to bank; 2 fiords; bridge
COT27	Upper	Moderately Impacted	Moderately Impacted	grazing; road adjacent to bank

Table 4-5 ***Comparison of most degraded reaches with target conditions – Cottonwood Creek***

	Target Variable	***Target Value (%)***	**COT20**	**COT21**	**COT1**	**COT9**	**COT14**	**COT23**	**COT24**	**COT27**
Vegetation	**Tree/shrub Types**	≥ ***84***	60	60	80	60	80	50	75	70
	Degraded Riparian Vegetation	≤ ***10***	61	69	18	35	29	49	27	39
Channel	**Channelized**	***0***	0	0	22	0	0	0	0	0
	Eroding Banks	≤ ***11***	35	11	17	34	29	42	31	30

4.3 Restoration Focus Areas

4.3.1 Previous Restoration Activities

In 1995, the NRCS conducted several restoration projects on privately owned and state land on Cottonwood Creek. **Table 4-6** describes the restoration projects that were detailed in the NRCS study. There was no information available regarding the success of these projects or describing whether the riparian management was continued past the 1995 study.

Table 4-6 ***1995 NRCS Restoration Projects***

Reachs	Owner	Riparian Fencing (ft)	Channel Improved* (ft)	Stream/Riparian Improved* (ft)	Off-site Watering Locations Provided	Comments
COT4/COT6	Dave Leinenger	6,330	None	9,480	Two	Restoration complete
COT13	Floyd Maxwell	None	None	None	One	Planning and design complete (as of 1995)

*No information was provided as to the improvement technique.

4.3.2 Restoration Priorities

For each of the "most degraded" reaches of Cottonwood Creek described in **Section 4.3**, this section summarizes the major impacts observed during the air photo assessment. Because of their heavily impacted condition, these reaches represent the areas most likely in need in restoration.

COT20 – The primary impact was to riparian vegetation; 61% of the riparian vegetation community was impacted. 35% of the channel was unstable or eroding, three times the reference value for Cottonwood Creek. Evidence of grazing and concentrated stock access points was noted. Proper riparian function may be improved by providing off-site watering locations coupled with riparian fencing. The tree/shrub cover was 60%, which was 24% below the average reference reach value.

COT21 – The channel was less degraded on COT21 than on its adjacent upstream reach COT20 (above). The channel condition met Cottonwood Creek reference conditions. The primary impact was to riparian vegetation; 69% of the riparian vegetation community was impacted. The tree/shrub cover was 60%, which was 24% below the average reference reach value. Evidence of grazing, concentrated stock water access points and numerous vehicle fjords across the stream were noted. Proper riparian function may be improved by providing off-site watering locations coupled with riparian fencing. The tree/shrub cover was 60%, which was 24% below the average reference reach value.

COT1 – This reach begins at the confluence of Cottonwood Creek and Big Spring Creek. COT1 was primarily affected by a long channelized section (22%). The riparian characteristic values were within 10% of target values. The value of bank erosion was within 10% of the target channel value. Restructuring of the channelized portion of the reach to a more sinuous condition will aid in reducing stream flow velocities. Maintenance of the current functioning riparian zone is recommended through riparian fencing and off-site watering locations.

COT9 – 35% of the riparian vegetation was degraded, three times the degraded vegetation reference value for Cottonwood Creek. Similarly, 34% of the channel was unstable or eroding, three times the channel reference value. The vegetation and channel conditions were primarily impacted by evidence of grazing and agricultural fields that came to the bank edge. The tree/shrub cover was 60%, which was 24% below the average reference reach value.

COT14 – There was 80% tree and shrub cover in the riparian zone. 29% of the riparian community was degraded, nearly 20% over the vegetation reference value. Similarly, 29% of the channel was unstable or eroding, nearly 20% over the channel reference value. The vegetation and channel conditions were primarily impacted by grazing and agricultural fields that came to the bank edge.

COT23 – 50% of the riparian zone consisted of trees and shrubs. Nearly 50% of the riparian vegetation on the reach was degraded. 42% of the banks on the reach were unstable or eroding. The riparian vegetation and channel were impacted by grazing, concentrated stock access and vehicle crossing.

COT24 – COT24 had 25% greater tree/shrub cover and a more healthy riparian and channel condition than its adjacent downstream reach, COT23 (above). The value of riparian degradation and channel instability/erosion exceeded the reference values by approximately 20%. Riparian function and channel stability were impacted by grazing and a dirt road and ranch on the stream bank.

COT27 - 39% of the riparian vegetation was degraded, nearly four times the degraded vegetation reference value for Cottonwood Creek. 30% of the channel was unstable or eroding, three times the channel reference value. The vegetation and channel conditions were primarily impacted by grazing and agricultural fields that came to the bank edge. The tree/shrub cover was 60%, which was 24% below the average reference reach value.

5.0 CONCLUSIONS

Degraded riparian vegetation appeared to be the most common impact to Beaver Creek and the greatest potential cause of increased sediment input. The primary sources of vegetation impacts were related to land use: agriculture and grazing appeared to have had significant impacts to riparian communities.

On the majority of the reaches, both the vegetation condition and the channel condition were classified as Moderately and Lightly Impacted.

Select riparian characteristics were compared to the total percentage of unstable and eroding banks in each reach in order to provide a quantitative estimate of the correlation between riparian vegetation and bank stability. Few if any connections between vegetation condition and bank stability were obvious from the comparison, suggesting that a more complicated set of circumstances controls bank stability on Cottonwood Creek, or possibly that are more detailed analysis is required to understand the causes of bank instability on Cottonwood Creek.

Across the entire length of Cottonwood Creek, conditions were generally good, with 25% of the riparian vegetation in a degraded condition and 16% of the banks in either unstable (10%) or severely eroding (6%) condition. Few permanent "hard" alterations to the stream have been made through channelization or riprap, suggesting that restoration potential is very good.

Table 5-1 ***Summary of Degradation Statistics***

Degraded Riparian Vegetation	Riprap	Channelization	Unstable Banks	Severely Eroding Banks
25%	0%	1%	10%	6%

The air photo assessment that was conducted for this report was not at a scale that allows for detailed site-specific restoration recommendations. However, the following general recommendations could guide restoration efforts, particularly in those reaches identified in **Section 4.3** as "most degraded" and thus most in need of restoration:

- Providing at least a 50 foot vegetation buffer between Cottonwood Creek and fields/roads;
- Improving proper riparian function by providing off-site watering locations coupled with riparian fencing;
- Enhancing the tree and woody shrub community where there is potential to aid in erosion reduction or maintenance of bank stability;
- Restructuring of the channelized portions of the reach to a more sinuous condition to aid in reducing stream flow velocities; and
- Mechanical bank stabilization where possible.

APPENDIX E

Modeling Approach

A simplistic modeling approach was applied to the Big Springs Creek watershed to estimate the natural and anthropogenic pollutant sources in the drainage, and provide insight on how loading reductions could be achieved through the implementation of best management practices (BMPs). The Spreadsheet Tool for Estimating Pollutant Loads (STEPL) was selected due to its relative ease in application, and the minimal driving data requirements. Different from many of its complex counterparts, STEPL calculates watershed loads on a yearly basis, neglecting process components such as infiltration, evaporation, and nutrient cycling. The model was initially developed to estimate load reductions for the Grant Reporting and Tracking System (GRTS) and was applied to the main stem of Big Springs Creek to provide a coarse numerical estimate of the pollutant load entering the stream. Implementation of the model is best suited for assessing the general source contribution of sediment and nutrient delivery from various land cover and land use.

To compliment the STEPL overland loading model, a secondary model component was added to estimate stream bank erosion. Stream bank erosion is typically omitted in most simple watershed-loading models and STEPL is no exception, accounting only for erosion that originates from raindrop impact and sheet flow. To assess the relative contribution of in-stream sources to the overall load in Big Springs Creek, the empirical Bank Erosion Hazard Index (BEHI) model (Rosgen, 2001) was used. The BEHI method is especially attractive due to the absence of site-specific recession data in the area. Used in combined with STEPL, a rudimentary estimate of the overall sediment and nutrient delivery to Big Springs Creek is possible. It is important to note that the empirical nature of STEPL and BEHI make the tools applicable for pollutant loading estimation only, not for direct TMDL target development or allocation of pollutant loads. Further descriptions of each of the models are provided in the following sections.

STEPL Model Description

The Spreadsheet Tool for Estimating Pollutant Loads (STEPL) was developed by the Environmental Protection Agency (EPA) to compute non-point source pollutant loads originating from urban, agricultural, and forested land use. The model employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various best management practices (BMPs). For each watershed, nitrogen, phosphorus, and 5-day biological oxygen demand (BOD-5) are estimated using surface water runoff volumes derived by the SCS runoff method and the pollutant concentrations in the runoff water. The annual sediment load from the various land use distribution and management practices is calculated using a sediment delivery ratio and the Universal Soil Loss Equation (USLE). Pollutant sources incorporated into the model include farm animals, feedlots, agriculture, urban runoff, and failing septic systems.

BEHI Model Description

The Bank Erosion Hazard Index (BEHI) provides a quantitative prediction of stream bank erosion rates and is an effective tool to allocate sediment contribution of stream bank sediment sources to the total sediment load. It is particularly advantageous for TMDL development (Rosgen, 2001). The premise of the model/classification system is that stream bank erosion is related to two factors: stream bank characteristics (erodibility potential) and hydraulic forces. The bank characteristics form the BEHI rating and incorporate such aspects as bank height to bankfull depth ratio, rooting depth to bank height ratio, slope steepness, root density, and percent of surface area of bank protected. A secondary index called Near Bank Stress (NBS) relates to the hydraulic forces within the channel and includes the vertical velocity gradient and the ratio of near-bank stress to overall shear stress. The BEHI system is collectively used to determine stream bank recession rates in feet per year. A more comprehensive description of the model is found in "*Applied River Morphology" 2001*.

Model Setup and Parameters

In order to speed the model setup process and increase the resolution of the driving data, the GIS interface for the Soil and Water Assessment Tool (SWAT) was utilized to determine land use and land cover information, soil erodibility and hydrologic soil group, watershed subbasin areas, and topographic factors. Raster datasets used during the process included the USGS Landcover and National Elevation Dataset (NED) and NRCS STATSGO soils grid. Rainfall intensity-depth-frequency (IDF), animal density, and septic contribution were provided through the STEPL Model Input Data Server or internal tables included in the STEPL worksheet.

For the purpose of modeling, the Big Springs Creek HUC (10040103) was subdivided into four subbasins to reflect the various changes in land use and their spatial distribution within the watershed. Criteria include major tributaries to Big Springs Creek, and known point sources. Table E-1 summarizes watershed parameters for each of the subbasins. Watershed boundaries are shown in Figure E-1.

Table E-1

WATERSHED	AREA (ACRES)	HYDROLOGIC SOIL GROUP	LAND USE DISTRIBUTION	K [1]	CN [2]	TOPOGRAPHY S [3]	L [4]
W1	88495	C	RANGE	0.29	74	9%	80
			CROP	0.32	82	4%	80
			FOREST	0.20	70	14%	80
			URBAN	---	88	---	---
			*USER DEF	0.35	99	1%	20
W2	77637	C	RANGE	0.20	74	8%	60
			CROP	0.30	82	4%	60
			FOREST	0.20	70	16%	60
			URBAN	---	88	---	---
			*USER DEF	0.35	99	1%	20
W3	71317	C	RANGE	0.25	74	8%	60
			CROP	0.31	82	5%	60
			FOREST	0.20	70	13%	60
			URBAN	---	88	---	---
			*USER DEF	0.35	99	1%	20
W4	18086	C	RANGE	0.35	74	9%	80
			CROP	0.30	82	4%	80
			FOREST	0.20	70	17%	80
			URBAN	---	88	---	---
			*USER DEF	0.35	99	1%	20

(1) Soil erodibility factor (from NRCS STATSGO grid)
(2) SCS curve number (McCuen, 1998)
(3) Slope steepness (GIS calculated from USGS LULC and DEM)
(4) Avg. slope length (GIS calculated from USGS DEM)

*USER DEF – combination of water and wetland LULC

Sediment Modeling

Modeling of the overall sediment delivery and load in the Big Springs Watershed was divided into two separate components. STEPL was used to assess sheet flow derived erosion (raindrop detachment and rill and interill erosion) originating from pervious land surfaces. BEHI was then applied to provide supporting information on stream bank erosion rates. The summation of the pollutant estimates from STEPL and BEHI result in a cumulative numerical load for each of the watersheds based on a given land use scenario (tons/year). Urban values are determined from a simple wash-off function and include the addition of known point sources, specifically the City of Lewistown wastewater treatment plant (WWTP). The applicability of the load value to the relative pollutant source contribution is for assessment purposes only, not to develop a numerical waste load target for TMDL planning.

Rill and Interill Erosion

STEPL computes rill and interill erosion using the Universal Soil Loss Equation (USLE). The generalized equation is one of the most widely used sheet erosion equations where soil loss (A) is a function of the rainfall erosivity index (R), soil erodibility factor (K), overland flow slope and length (LS), crop management factor (C), and conservation practice factor (P). The USLE is shown below.

$$A = RK(LS)CP \text{ (in tons/acre/year)}$$

Although USLE calculates soil erosion for a given slope, much of the eroded soil in a watershed is not delivered to a point downstream. Rather, it is re-deposited at locations where the momentum of transporting water is insufficient to keep the material in suspension or to move the soil particles along the watershed surface. To compensate for deposition, a sediment delivery ratio (SDR) is applied to the USLE estimate to determine gross erosion for the watershed. The SDR is based entirely on watershed area and reflects the actual percentage of sediment that it delivered to the waterway. The value is then combined with stream bank erosion and urban sediment sources to determine the total sediment load for the watershed.

Erosion Scenarios

Due to the uncertainty in applying empirically based models to watershed specific conditions and the wide range of USLE variables, sediment pollutant loads were estimated for several different scenarios. These include:

- Natural conditions with no urban or agricultural influence.
- Existing conditions based on low erosion potential.
- Existing conditions based on high erosion potential.

Assumptions made for each of the scenarios above are presented in Table E-2. Existing conditions reflect the probable field conditions and variation of literature based modeling coefficients. Default export mean coefficient (EMC) model values were used for impervious surfaces and calculation of total suspended solids (TSS) loading from urban runoff.

Table E-2

SCENARIO	CROPLAND [1]	RANGELAND [2]	FOREST [3]
Natural Conditions	• Canopy cover; short brush (20 inch fall height) 25% • Surface cover; grass/litter layer • Percent ground cover; 70-80%	• Canopy cover; short brush (20 inch fall height) 25% • Surface cover; grass/litter layer • Percent ground cover; 70-80%	• Undisturbed woodlands • Effective canopy cover; 70-80% • Forest litter; 90-100%
	C value = 0.02	**C value = 0.02**	**C value = 0.001**
Existing Conditions – Low Sediment Delivery	• 4 year rotation cycle, wheat (1) - alfalfa (3) • Intermediate spring wheat stubble between plantings	• Canopy cover; short brush (20 inch fall height) 25% • Surface cover; grass/litter layer • Percent ground cover; 60-70%	• Undisturbed woodlands • Effective canopy cover; 50-60% • Forest litter; 70-80%
	C value = 0.05	**C value = 0.03**	**C value = 0.003**
Existing Conditions – High Sediment Delivery	• 50% spring wheat, stubble with fall turnplow • 50% alfalfa	• Canopy cover; short brush (20 inch fall height) 25% • Surface cover; grass/litter layer • Percent ground cover; 50-60%	• Undisturbed woodlands • Effective canopy cover; 30-40% • Forest litter; 50-60%
	C value = 0.14	**C value = 0.06**	**C value = 0.006**

(1) McCuen, 1998
(2) Brooks, 1997
(3) Maidment, 1993

The remaining USLE parameters were developed through GIS spatial analyses including (LS)-overland flow length and slope and (K)-soil erodibility factor. These have been identified as part of the subbasin parameters in Table E-1. The rainfall erosivity index values (R) were taken from the STEPL database and vary by land use, roughly correlating to topography and orographic influences in the watershed. All conservation practice factors (P) were set to unity, meaning no conservation practice was applied.

Stream Bank Erosion

The BEHI stream bank erosion model relies on empirically based bank recession studies and field interpretation of the various components of the stream system. BEHI scoring results (depend on stream bank characteristics) and the NBS rating (hydraulic forces) result in a cumulative index that translates to a category of either low, moderate, high, very high, or extreme stream bank erosion. Bank recession values are than determined from one of four different regression curves that vary in magnitude from between 0.02-3 feet per year. The NBS ratings for Big Springs Creek were developed from surveyed cross sections in watershed W1, W3, and W4 and cumulative BEHI scores for each subbasin were estimated using the DEQ aerial assessment and NRCS ground truth. Although certain parameters required professional judgment due to a lack of site-specific data, it is assumed that the model provides a reasonable estimate of stream bank erosion. Many of the logistics of the BEHI model are beyond the scope of this document and the reader is recommended to consult the appendix for further information.

Nutrient Modeling

The nutrient modeling capability of STEPL is limited to the use of event mean concentration (EMC) coefficients to calculate the total load of nitrogen, phosphorus, and 5-day BOD in stormwater runoff. The underlying premise is that overland flow from various land uses produces a specific mass of pollutant per unit runoff volume. Excess rain values are derived from the SCS curve number method and the total EMC pollutant load (mg/L) is applied to this volume. Additional mass is introduced to the system through soil erosion from USLE, stream bank erosion, and City of Lewistown WWTP discharge effluent. Soil loss loading (both sheet flow and stream bank erosion) is identified by the relative nutrient enrichment ratio of the eroded soil and the specific percentage of N, P, and BOD in the soil matrix (N-0.01%, P-0.004%, and BOD-0.02% for the Lewistown area). Yearly nutrient loads of N and P were provided by the City of Lewistown and BOD demand was based off of daily per capita average (Chapra, 1997).

In order to compensate for some of the underlying deficiencies in the STEPL nutrient model, EMCs were calibrated to existing water quality/discharge data to provide site-specific loading coefficients. Although this procedure largely neglects in-stream nutrient cycling processes, calibrated EMCs for Big Springs Creek are well within the limits of the available literature sources, including the PLOAD user’s manual (developed for EPA) and guidance documents published by the EPA Nationwide Urban Runoff Program (NURP). Event mean concentration values used during Big Springs Creek Modeling are shown in Table E-3. Default model values were used for urban lands.

Table E-3

SCENARIO	LAND USE	TOTAL N (MG/L)	TOTAL P (MG/L)	BOD-5 (MG/L)
NATURAL CONDITIONS	RANGE CROP FOREST WETLAND-WATER	1.1 1.1 1.1 0	0.10 0.10 0.10 0	4 4 4 0
EXISTING CONDITIONS	RANGE CROP FOREST WETLAND-WATER	1.9 2.2 1.1 0	0.15 0.15 0.10 0	5 5 5 0

PLOAD user manual values (CH2M HILL, 2000)

Modeled results should be used with discretion due to a limited number of published EMC values and the underlying assumptions regarding in-stream processes. Actual loading values may vary significantly due to pollutant uptake by biomass.

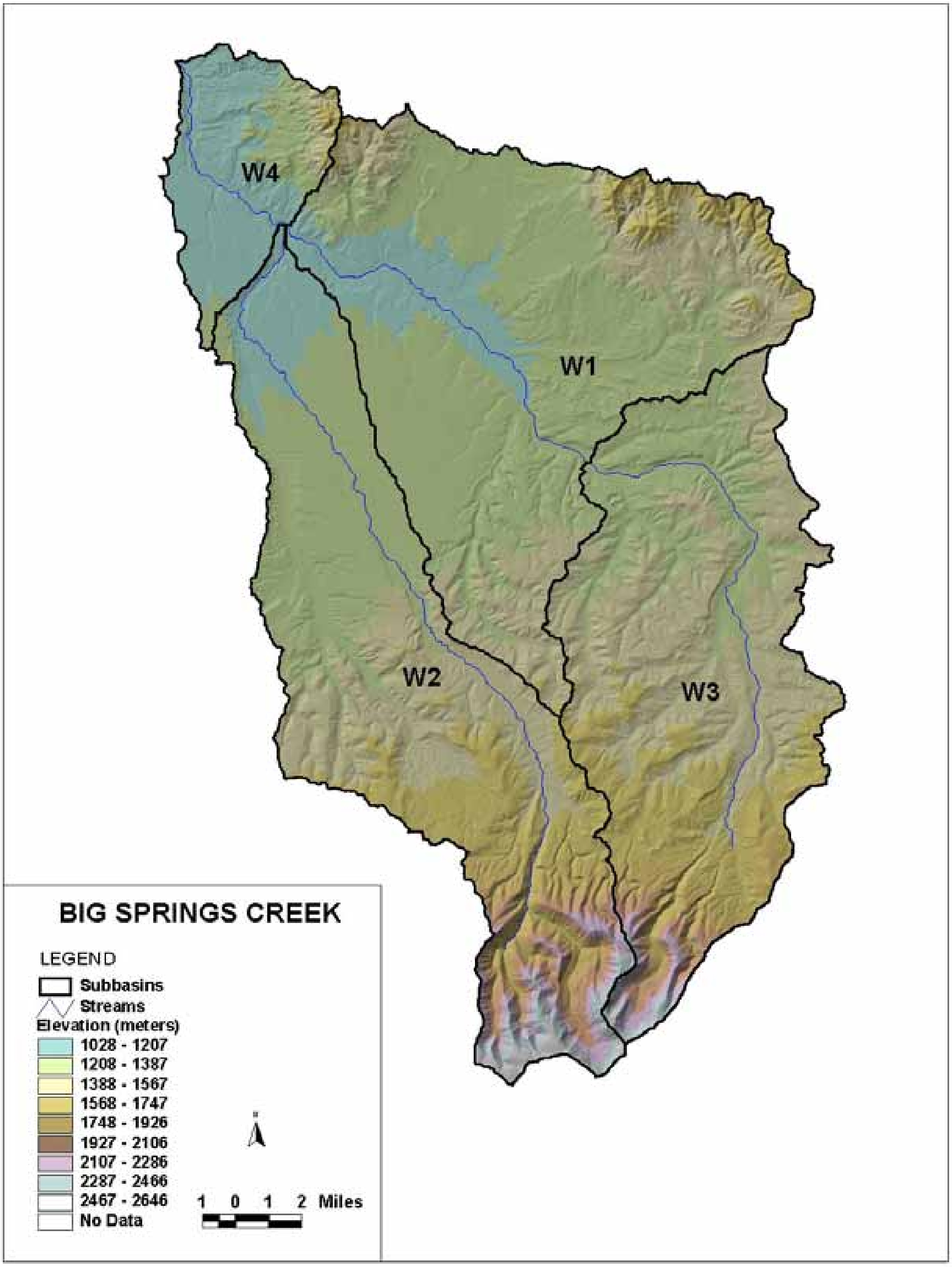

Figure E-1. Watershed Subbasins.

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WATERSHED 3
SCENARIO - LOW SEDIMENT DELIVERY

STREAMBANK MODEL [1]					STEPL MODEL				TOTAL LOAD				DISCHARGE		
	SED (TON/YR)	N [4] (LB/YR)	P [4] (LB/YR)	BOD (LB/YR)	SED (TON/YR)	N (LB/YR)	P (LB/YR)	BOD (LB/YR)	SED (TON/YR)	N (LB/YR)	P (LB/YR)	BOD (LB/YR)	Q [5] (AC-FT)	BAS [5] (CFS)	QT (AC-FT)
NATURAL [2]	620	2,480	992	4,960	500	33,030	3,620	116,840	1,120	35,510	4,612	121,800	10,490	110	90,100
55% STREAMBANK EROSION (W3)					MODELED NATURAL (MG/L)				9	0.15	0.02	0.50			
45% RILL & INTERILL EROSION (W3)															
EXISTING [3]	620	2,480	992	4,960	820	48,800	4,190	147,610	1,440	51,280	5,182	152,570			
43% STREAMBANK EROSION (W3)					MODELED EXISTING (MG/L)				12	0.21	0.02	0.62			
57% RILL & INTERILL EROSION (W3)					OBSERVED (MG/L)				13	0.26	0.01	---			
	SED (TON/YR)	N [4] (LB/YR)	P [4] (LB/YR)	BOD (LB/YR)	SED (TON/YR)	N (LB/YR)	P (LB/YR)	BOD (LB/YR)	SED (TON/YR)	N (LB/YR)	P (LB/YR)	BOD (LB/YR)			
ANTPG LOAD	0	0	0	0	320	15,770	570	30,770	320	15,770	570	30,770			
TOTAL LOAD	620	2,480	992	4,960	820	48,800	4,190	147,610	1,440	51,280	5,182	152,570			
PERCENT	0%	0%	0%	0%	39%	32%	14%	21%	22%	31%	11%	20%			

[1] Rosgen BEHI streambank erosion model
[2] Conditions with no agricultural or urban land use practices
[3] Existing land use practices/conditions
[4] Nutrient enrichment ratio of 2; 0.1% N content in soil, 0.04% P, 0.2% BOD
[5] SCS runoff volume (acre-feet); estimated baseflow in cfs (USGS - NRCS records)

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WATERSHED 1
SCENARIO - LOW SEDIMENT DELIVERY

STREAMBANK MODEL [1]					**STEPL MODEL**				**TOTAL LOAD**				**DISCHARGE**		
	SED (TON/YR)	N [4] (LB/YR)	P [4] (LB/YR)	BOD (LB/YR)	SED (TON/YR)	N (LB/YR)	P (LB/YR)	BOD (LB/YR)	SED (TON/YR)	N (LB/YR)	P (LB/YR)	BOD (LB/YR)	Q [5] (AC-FT)	BAS [5] (CFS)	QT (AC-FT)
NATURAL [2]	5,140	20,560	8,224	41,120	900	48,900	5,550	171,950	6,040	69,460	13,774	213,070	15,740	65	62,800
COMBINE W1-W3	5,760	23,040	9,216	46,080	1,400	81,930	9,170	288,790	7,160	104,970	18,386	334,870	26,230	175	152,900
85% STREAMBANK EROSION (W1)					MODELED NATURAL (MG/L)				34	0.25	0.04	0.81			
15% RILL & INTERILL EROSION (W1)															
EXISTING [3]	6,440	25,760	10,304	51,520	1,620	87,500	8,240	231,810	8,060	113,260	18,544	283,330			
WWTP EFFL [6]	0	0	0	0	0	0	0	0	30	48,470	8,100	583,500			
COMBINE W1-W3	7,060	28,240	11,296	56,480	2,440	136,300	12,430	379,420	9,530	213,010	31,826	1.0E+06			
80% STREAMBANK EROSION (W1)					MODELED EXISTING (MG/L)				46	0.51	0.08	2.45			
20% RILL & INTERILL EROSION (W1)					OBSERVED (MG/L)				5**	0.42**	0.05	---			
	SED (TON/YR)	N [4] (LB/YR)	P [4] (LB/YR)	BOD (LB/YR)	SED (TON/YR)	N (LB/YR)	P (LB/YR)	BOD (LB/YR)	SED (TON/YR)	N (LB/YR)	P (LB/YR)	BOD (LB/YR)			
ANTPG LOAD	1,300	5,200	2,080	10,400	720	38,600	2,690	59,860	2,050	92,270	12,870	653,760			
TOTAL LOAD	6,440	25,760	10,304	51,520	1,620	87,500	8,240	231,810	8,090	161,730	26,644	866,830			
PERCENT	20%	20%	20%	20%	44%	44%	33%	26%	25%	57%	48%	75%			

[1] Rosgen BEHI streambank erosion model
[2] Conditions with no agricultural or urban land use practices
[3] Existing land use practices/conditions
[4] Nutrient enrichment ratio of 2; 0.1% N content in soil, 0.04% P, 0.2% BOD
[5] SCS runoff volume (acre-feet); estimated baseflow in cfs (USGS - NRCS records)
[6] Values provided by city of Lewistown (P & N), BOD based on per capita average of 0.275 lb/day for 5813 people (2000 census)
**Approximated on very limited data

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WATERSHED 2
SCENARIO - LOW SEDIMENT DELIVERY

STREAMBANK MODEL [1]					**STEPL MODEL**				**TOTAL LOAD**				**DISCHARGE**		
	SED	**N [4]**	**P [4]**	**BOD**	**SED**	**N**	**P**	**BOD**	**SED**	**N**	**P**	**BOD**	Q [5]	BAS [5]	**QT**
	(TON/YR)	**(LB/YR)**	**(LB/YR)**	**(LB/YR)**	**(TON/YR)**	**(LB/YR)**	**(LB/YR)**	**(LB/YR)**	**(TON/YR)**	**(LB/YR)**	**(LB/YR)**	**(LB/YR)**	**(AC-FT)**	**(CFS)**	**(AC-FT)**
NATURAL [2]	0	0	0	0	400	39,000	4,040	139,250	400	39,000	4,040	139,250	12,530	10	19,800
EMPHEMERAL								MODELED NATURAL (MG/L)	15	0.72	0.08	2.59			
EXISTING [3]	0	0	0	0	780	63,010	5,350	177,420	780	63,010	5,350	177,420			
EMPHEMERAL								MODELED EXISTING (MG/L)	29	1.17	0.10	3.30			
								OBSERVED (MG/L)	---	---	---	---			
	SED	N [4]	P [4]	BOD	SED	N	P	BOD	SED	N	P	BOD			
	(TON/YR)	(LB/YR)	(LB/YR)	(LB/YR)	(TON/YR)	(LB/YR)	(LB/YR)	(LB/YR)	(TON/YR)	(LB/YR)	(LB/YR)	(LB/YR)			
ANTPG LOAD	0	0	0	0	380	24,010	1,310	38,170	380	24,010	1,310	38,170			
TOTAL LOAD	0	0	0	0	780	63,010	5,350	177,420	780	63,010	5,350	177,420			
PERCENT	0%	0%	0%	0%	49%	38%	24%	22%	49%	38%	24%	22%			

[1] Rosgen BEHI streambank erosion model
[2] Conditions with no agricultural or urban land use practices
[3] Existing land use practices/conditions
[4] Nutrient enrichment ratio of 2; 0.1% N content in soil, 0.04% P, 0.2% BOD
[5] SCS runoff volume (acre-feet); estimated baseflow in cfs (USGS - NRCS records)

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WATERSHED 4
SCENARIO - LOW SEDIMENT DELIVERY

STREAMBANK MODEL [5]					**STEPL MODEL**				**TOTAL LOAD**				**DISCHARGE**		
	SED (TON/YR)	N [4] (LB/YR)	P [4] (LB/YR)	BOD (LB/YR)	SED (TON/YR)	N (LB/YR)	P (LB/YR)	BOD (LB/YR)	SED (TON/YR)	N (LB/YR)	P (LB/YR)	BOD (LB/YR)	Q [3] (AC-FT)	BAS [3] (CFS)	QT (AC-FT)
NATURAL [1]	4,780	19,120	7,648	38,240	380	11,070	1,480	37,760	5,160	30,190	9,128	76,000	3,200	5	6,800
COMBINE ALL	10,540	42,160	16,864	84,320	2,180	132,000	14,690	465,800	12,720	174,160	31,554	550,120	41,960	190	179,500
93% STREAMBANK EROSION (W4)					MODELED NATURAL (MG/L)				52	0.36	0.06	1.13			
7% RILL & INTERILL EROSION (W4)															
EXISTING [2]	5,580	22,320	8,928	44,640	650	19,710	2,100	48,570	6,230	42,030	11,028	93,210			
COMBINE ALL	12,640	50,560	20,224	101,120	3,870	219,020	19,880	605,410	16,540	318,050	48,204	1.3E+06			
90% STREAMBANK EROSION (W4)					MODELED EXISTING (MG/L)				68	0.65	0.10	2.64			
10% RILL & INTERILL EROSION (W4)					OBSERVED (MG/L)				---	0.4-0.7**	0.02	---			
	SED (TON/YR)	N [4] (LB/YR)	P [4] (LB/YR)	BOD (LB/YR)	SED (TON/YR)	N (LB/YR)	P (LB/YR)	BOD (LB/YR)	SED (TON/YR)	N (LB/YR)	P (LB/YR)	BOD (LB/YR)			
ANTPG LOAD	800	3,200	1,280	6,400	270	8,640	620	10,810	1,070	11,840	1,900	17,210			
TOTAL LOAD	5,580	22,320	8,928	44,640	650	19,710	2,100	48,570	6,230	42,030	11,028	93,210			
PERCENT	14%	14%	14%	14%	42%	44%	30%	22%	17%	28%	17%	18%			
CUM APG LOAD	2,100	8,400	3,360	16,800	1,690	87,020	5,190	139,610	3,820	143,890	16,650	739,910			
CUM LOAD	12,640	50,560	20,224	101,120	3,870	219,020	19,880	605,410	16,540	318,050	48,204	1.3E+06			
CUM PERCENT	17%	17%	17%	17%	44%	40%	26%	23%	23%	45%	35%	57%			

[1] Rosgen BEHI streambank erosion model
[2] Conditions with no agricultural or urban land use practices
[3] Existing land use practices/conditions
[4] Nutrient enrichment ratio of 2; 0.1% N content in soil, 0.04% P, 0.2% BOD
[5] SCS runoff volume (acre-feet); estimated baseflow in cfs (USGS - NRCS records)
**Approximated on very limited data

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